THE INSTITUTE OF PHYSICS

BULLETIN

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THE INSTITUTE OF PHYSICS

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47 BELGRAVE SQUARE, LONDON, S.W.1. TELEPHONE : BELGRAVIA 6111-2-3

Appointments Vacant

The inclusion of particulars of a vacancy must not be taken to imply that the Institute necessarily approves of the terms offered or that might be offered. Candidates should satisfy themselves that these are satisfactory, and they may always refer to the Institute for advice.

PHYSICIST. If you have a good honours degree in physics and some experience in model work and would like to join the Commonwealth's largest glass manufacturing organization you are invited to write about yourself to the Personnel Officer (Graduate Recruitment), Pilkington Brothers Limited, St. Helens, Lancashire. You would have a leading part in setting up a new model laboratory where air and water model techniques will be used to study flow pattern of glass in melting units. Particular attention will also be paid to the study of combustion conditions with reference to port and regenerator design.

MATHEMATICIANS, SCIENTISTS AND ENGINEERS required by Army Operational Research Organization (War Office), West Byfleet, Surrey, for assessment of performance and potentialities of weapons and equipment, study of problems connected with tactics and conduct of military operations, supply and maintenance of military stores, human performance and selection and training of manpower. Scope for use of practically all scientific training provided this is backed by a certain minimum mathematical ability. Work is varied and interesting and there are laboratory and workshop facilities. Appointments in grade of (*a*) Scientific Officer (£615 to £1,090) or (*b*) Senior Scientific Officer (minimum age 26 and at least three years' postgraduate research experience) (£1,166 – £1,380). First or second class honours degree or equivalent required for both. Superannuation under F.S.S.U. Those under 31 have opportunities for establishment. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A198/OA.

MAKERERE COLLEGE
THE UNIVERSITY COLLEGE OF EAST AFRICA

SCIENTIFIC INSTRUMENT MECHANIC required to take charge of Faculty of Science Workshop. Duties include repair, maintenance and construction of scientific apparatus and supervision of workshop staff. Salary scale : £1,098 – £1,710 p.a., entry point determined by qualifications and experience. Superannuation. Child allowance £50 p.a. per child (maximum £150 p.a.). Passages for appointee and family (up to four adult passages) on appointment, termination and leave (three months every 21 months). Rent (including basic furniture) according to quarters provided £45 – £84 p.a. Detailed applications (6 copies) naming three referees by June 30, 1960, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

ESSEX COLLEGE
ASSUMPTION UNIVERSITY OF WINDSOR
WINDSOR, ONTARIO, CANADA

The Department of Physics offers GRADUATE ASSISTANTSHIPS to candidates wishing to proceed to an M.Sc. in physics. Stipend up to $2,000 for eight months, depending on qualifications and duties in the department. There is a possibility of additional income during the summer months. At present research is proceeding in beta ray spectroscopy, solid state physics and molecular collision problems. Enquiries should be addressed to The Chairman, Department of Physics, Essex College, Assumption University, Windsor, Ontario, Canada.

ESSEX COLLEGE
ASSUMPTION UNIVERSITY OF WINDSOR
WINDSOR, ONTARIO, CANADA

The Department of Physics invites applications for a staff position in experimental physics. The duties will include instruction in undergraduate and graduate courses. Preference will be given to candidates with interests in low energy nuclear physics, solid state physics or molecular spectroscopy. The rank and salary will depend upon qualifications and experience but will not be less than $6,800 at the Ph.D. level. Enquiries should be addressed to The Chairman, Department of Physics, Assumption University, Windsor, Ontario, Canada.

FULMER RESEARCH INSTITUTE LIMITED

Requires PHYSICAL CHEMISTS, METAL PHYSICISTS, and METALLURGISTS equivalent in status to Scientific and Senior Scientific Officers, to work on fundamental properties and structures of alloys including those of aluminium, zirconium and uranium. Candidates should be of honours degree standard and preferably have some research experience. For one of the posts experience in electronics would be an advantage. Applications should be addressed to :—Director of Research, Fulmer Research Institute Ltd., Stoke Poges, Buckinghamshire.

BATTERSEA COLLEGE OF TECHNOLOGY
LONDON, S.W.11
(A College of Advanced Technology)

Application is invited for two GRADE B LECTURESHIPS from graduates of a British University. One with qualifications and experience in electronics, the other in theoretical and nuclear physics. Salary for a good honours graduate with at least two years' experience within the range £988 to £1,396. Further particulars from the Clerk to the Governing Body by whom applications should be received as soon as possible.

VICTORIA UNIVERSITY OF WELLINGTON
NEW ZEALAND

SENIOR LECTURER AND LECTURER IN PHYSICS

Applications are invited for the abovementioned posts. The salary for a Senior Lecturer is £1,750 per annum, rising by two annual increments of £100 and one increment of £50 to £2,000 per annum, and for a Lecturer £1,250 per annum, rising by annual increments of £75 to £1,700 per annum. In each case initial salary will be determined according to the qualifications and experience of the appointee. Approved fares to Wellington will be allowed for the appointee, his wife and his dependent children. Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in New Zealand and London, on July 1, 1960.

THE UNIVERSITY OF LEEDS
S.A.T.R.A. FELLOWSHIP

Applications are invited from graduates, or students graduating shortly, in physics or physical chemistry, for the S.A.T.R.A. Research Fellowship, normally of the annual value of £400 plus fees but rising to £500 in exceptional circumstances. The Fellowship has been established by the British Boot, Shoe and Allied Trades Research Association for the encouragement of fundamental research in physics in relation to the properties and behaviour of leather. The problems undertaken will fall either in the field of rheology, or of the properties of porous solids. It is tenable normally for two years and the Fellow may apply for acceptance as a candidate for a higher degree (M.Sc., Ph.D.). Applications (three copies) should reach the Registrar, The University, Leeds, 2 (from whom further particulars may be obtained) not later than June 22, 1960.

RHODES UNIVERSITY
SOUTH AFRICA

PROFESSOR OF APPLIED MATHEMATICS

Applications are invited for the abovementioned post, as from January 1, 1961. Applicants should be specialists in either applied mathematics or theoretical physics. The salary scale is £2,200 × £100 – £2,700 per annum. A Vacation Savings Bonus, as in the Public Service, is also payable. Full particulars and application forms may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in South Africa and London, on July 15, 1960.

COMMONWEALTH OF AUSTRALIA

WEAPONS RESEARCH ESTABLISHMENT

Research in Optics

The Department of Supply invite applications for the following vacancy at the Weapons Research Establishment, Salisbury, near Adelaide, South Australia :—

Position and Salary : SCIENTIFIC OFFICER, GRADE 1 : £A1,510/1,895.

Duties (Pos. No. 156) : Research and development on frequency response techniques in optics.

Qualifications : Honours degree in Mathematics or Physics. Relevant experience desirable.

Conditions : Under specified conditions, first class air/sea transport for the appointee and dependants (wife and dependent children) will be provided by the Commonwealth. Assistance will be given in obtaining housing accommodation.

Contract Employment : If desired by the successful candidate consideration may be given to entering into an agreement for a three (3) or five (5) year contract of employment in Australia. In this case the Commonwealth will bear the cost of return fares, together with the cost of removing the successful applicant's furniture and effects up to a maximum cost of £500 (Australian), £250 each way.

Applications : Forms obtainable from the Senior Representative (AV.63/7), Department of Supply, Australia House, Strand, London, W.C.2, with whom completed applications should be lodged by July 11, 1960.

AEI

Graduates in Electrical Engineering or Physics, or holders of the H.N.C. in Electrical Engineering, are required in a Higher Voltage Research Laboratory for experimental research on High Voltage problems. The work covers a wide range and includes the construction and use of impulse voltage and impulse current generators, high direct voltage generators, and electronic equipment.

Applicants should be able to carry out investigations without close supervision.

Previous works' training and laboratory experience are desirable but not essential.

The appointments are permanent and pensionable ; the starting salary will be in accordance with qualifications and experience.

Please write quoting reference L.15 for application form to: Personnel Manager
Associated Electrical Industries (Manchester) Ltd.
Trafford Park, Manchester, 17.

THE ENGLISH ELECTRIC VALVE COMPANY LIMITED

Chelmsford, Essex

has a vacancy for

DEVELOPMENT ENGINEER/ PHYSICIST

to undertake work on

Special Cathode Ray Tubes

Applications are invited from professional engineers of approximately thirty years of age, who apart from qualifications of graduate status should be able to offer at least five years' experience on similar or allied work in the valve industry.

A commencing salary of up to £1,200 per annum is envisaged and assistance with removal expenses may be made available to the successful applicant.

All replies should be addressed to Dept. CPS, Marconi House, 336/7 Strand, London, W.C.2, quoting reference IB 1595B.

CENTRAL ELECTRICITY GENERATING BOARD

RESEARCH AND DEVELOPMENT DEPARTMENT

Research Laboratories, Leatherhead, Surrey

FLUID DYNAMICS SECTION

Ref. PB/199

ENGINEERS AND PHYSICISTS

are required for the newly formed **Fluid Dynamics Section** that will cover a wide range of problems, including the accurate measurement of large flows of liquid and gases in power stations ; model investigations of the flow pattern near closely grouped cooling towers, detailed studies of the flow in tube banks of heat exchangers and in fuel element channels of nuclear reactors, the distribution of pulverized coal to the burners of power station boilers, etc., and there is ample scope for both fundamental and applied research.

Candidates for senior vacancies should have an honours degree and previous research experience in fluid dynamics ; for the other vacancies applicants should have a degree, or equivalent, and some experience in a related field is desirable. Applications from recent graduates, and students who expect to graduate this year, will be welcomed.

Salaries on scales within the range £1,195 – £1,775 p.a., or £570 – £1,300 p.a., according to duties and responsibilities.

HEAT TRANSFER SECTION

Ref. PB/163

CHEMICAL ENGINEERS, MECHANICAL ENGINEERS AND PHYSICISTS

are required with a sound knowledge of mass and heat-transfer. The work will consist of making a scientific analysis of the performance of large plants, with the object of improving efficiency and developing accurate design methods. There is ample scope for both fundamental and applied research and good experimental facilities are available.

Applicants should have an honours degree and, for the higher grades, considerable research experience in this field. Applications from newly qualified graduates will also be welcome.

Salaries according to duties and responsibilities, will be on scales within the range £1,195 – £1,775 p.a., or, up to £1,300 p.a.

There are good opportunities for promotion to higher grades. Where necessary, consideration may be given for financial assistance towards house purchase.

Applications stating age, qualifications, experience, present position and salary, to the Personnel Officer, 24/30 Holborn, London, E.C.1, as soon as possible. Envelopes should be marked "Confidential," quoting relevant reference number.

EXPERIMENTALIST

required at

ATOMIC ENERGY RESEARCH ESTABLISHMENT HARWELL

to work in the **PROTON PHYSICS GROUP** of the Nuclear Physics Division engaged in the investigation of various methods, such as plating and vacuum evaporation, for producing thin targets for exposure in the Proton Linear Accelerator and also to work on nuclear detectors and to participate in the experimental work of the group which is using the P.L.A. for studying nuclear structure.

Applicants should have G.C.E. at "A" level, H.N.C. or equivalent and appropriate experience.

Salary £1,045 – £1,285 p.a.

Housing and contributory pension scheme.

Send POSTCARD to Senior Recruitment Officer (1672/110), U.K.A.E.A., A.E.R.E., Harwell, Didcot, Berks.

RESEARCH INSTITUTE (ANIMAL VIRUS DISEASES), PIRBRIGHT, has a vacancy in Biophysics Section for young GRADUATE interested in investigation of virus and antibody systems by such methods as electron-microscopy, analytical ultracentrifugation and optical analysis generally. Qualifications: honours degree in physics or physical chemistry. Appointment in Scientific Officer Grade (£615 – £1,120). Suitably qualified candidate would be encouraged to work for higher degree. Starting salary dependent upon qualifications and experience. Superannuation under F.S.S.U. House available for married applicant. Applications to the Secretary.

THE UNIVERSITY OF LEEDS
HOULDSWORTH SCHOOL OF APPLIED SCIENCE

Applications are invited for the appointment of a THERMAL SYNDICATE RESEARCH FELLOW, for research on the physics of silica glass, in the Ceramics Division of the School on a stipend within the range £700 – £1,200 a year, according to age, qualifications and experience. The Fellowship will be tenable for one year in the first instance, renewable. Applications (three copies) stating date of birth, qualifications and experience, together with the names of two referees, should reach the Registrar, The University, Leeds, 2 (from whom further particulars may be obtained) not later than June 28, 1960.

FRESH GRADUATES in physics or chemistry required to join research teams in the following fields: (1) semiconductors and devices, (2) thin electrical films: memory storage devices, electrical resistors, vacuum techniques, (3) dielectric and magnetic ceramics. Starting salaries £850 p.a. or more according to background. Excellent prospects and conditions. G. V. Planer Ltd., Windmill Road, Sunbury-on-Thames, Middlesex (Sunbury 2266).

CANBERRA UNIVERSITY COLLEGE
AUSTRALIA
CHAIR OF MATHEMATICS

Applications are invited for appointment to the above-mentioned Chair. In 1960 the College will become part of the Australian National University and its present functions will be continued. Further details of the association are given in the information sheets for applicants. Salary ranges are now under review. At present the salary of a Professor is £A3,552 p.a. Further information and the summary forms which must accompany an application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close in Australia and London, on June 30, 1960.

ROYAL TECHNICAL COLLEGE
SALFORD
ELECTRICAL ENGINEERING DEPARTMENT

Head of Department: J. H. Calderwood, M.Eng., Ph.D., A.M.I.E.E., F.Inst.P.

Due to continued expansion of this College of Advanced Technology, a limited number of vacancies exist for staff at all levels from Assistant Lecturer to Reader. Salaries range from £700 to £2,100 p.a., or possibly higher in exceptional cases. Applicants should be pursuing active careers as electrical engineers or physicists. Considerable importance will be attached to proven ability in research, and commencing salaries will be commensurate with past achievement. Lecturing hours, and equipment available, are such that a genuine opportunity exists for original work. Certain posts are primarily research appointments. Further particulars and forms of application are available from the Registrar, Royal Technical College, Salford, Lancs. (please quote ref. B.I.P.), to whom applications should be returned by June 25, 1960.

UNIVERSITY OF ABERDEEN

RESEARCH ASSISTANT required to work personally with Professor R. V. Jones, mainly on the design and use of scientific instruments, in the Natural Philosophy Department, University of Aberdeen. Salary, which is provided by the Royal Society Warren Research Fund, £900 – £1,100 per annum with superannuation. Post tenable for four years in the first instance. Qualifications required are skill and ingenuity; Higher National Certificate, Degree, or equivalent, an advantage. Apply, giving qualifications and experience, to The Secretary, The University, Aberdeen.

The Scientific Civil Service needs men and women for pensionable posts as (*a*) SENIOR SCIENTIFIC OFFICERS and (*b*) SCIENTIFIC OFFICERS in all major scientific fields, including physics, engineering, chemistry, meteorology, mathematics and biology. Age limits: (*a*) at least 26 and under 32, (*b*) at least 21 and under 29. Extension for regular Forces Service and Overseas Civil Service. Qualifications: normally first or second class honours degree in science, mathematics or engineering, or equivalent attainment; additionally for (*a*) at least three years' relevant (e.g. postgraduate) experience. London salaries (men): (*a*) £1,233 – £1,460; (*b*) £655 – £1,150; provision for starting pay above minimum. Promotion prospects. Write Civil Service Commission, 17 North Audley Street, London, W.1. for application form, quoting (*a*) S/53/60, (*b*) S/52/60.

UNIVERSITY COLLEGE OF NORTH WALES, BANGOR
DEPARTMENT OF ELECTRICAL ENGINEERING

Applications are invited for the post of LECTURER in materials technology. Applicants should have a thorough knowledge of the physics of materials and should have industrial or research experience involving semiconductors, polymers, magnetic materials, etc. The salary scale for a lecturer is £1,050 – £1,850 p.a., and the initial salary will depend on the qualifications and experience of the person appointed. In addition there are F.S.S.U. benefits and family allowances. The appointment will date from September 1, 1960, or from a date to be arranged with the successful candidate. Two copies of the application should be sent, not later than June 30, to the Registrar, from whom further particulars may be obtained.

ALUMINIUM LABORATORIES LTD. (The Research and Technical Organization of the International ALCAN Group of Companies) require a UNIVERSITY GRADUATE with experience in X-ray crystallography, for metallurgical investigations in this field. The work is varied with opportunity for research of a long-term nature suitable for publication. Pension and Life Assurance Scheme in operation. For further details please apply to: Personnel Officer, Southam Road, Banbury, Oxon.

Supplement to the BULLETIN *of The Institute of Physics, June, 1960*

Physics Courses in Colleges of Technology 1960-61

This supplement contains announcements of physics courses and special lectures that will be available during the 1960-61 session in some of the principal Colleges of Technology. It is hoped that this will be of use to students, to young graduates wishing to know of postgraduate lectures and to senior members of the Institute concerned with the training of assistants.

Sunderland Education Authority

SUNDERLAND TECHNICAL COLLEGE

SESSION 1960-61

COURSES IN PURE AND APPLIED PHYSICS

1. **Diploma in Technology—Applied Physics**
   A four year "Sandwich" course in Applied Physics will commence in October. The course will provide a training for the industrial physicist and has an emphasis on electronics. The Diploma gives exemption from the academic requirements of The Institute of Physics for Graduate membership.
2. **B.Sc. Pure Science**
   A three year full-time course for the external B.Sc. General Degree of London University is offered in the subjects of Physics, Mathematics and Chemistry.
3. **National Certificate in Applied Physics**
   Part-time day and evening courses are provided for the Ordinary and Higher National Certificate and for Post-Certificate qualification in Electronics and Mathematics.
4. **Graduateship of The Institute of Physics**
   Part-time classes are provided for suitably qualified students.
5. **Short Courses**
   (*a*) Application of Transistors and Semiconductor Devices (first term).
   (*b*) Photoelasticity (first term).
   (*c*) High Vacuum Technology (second term).

Further details of these courses may be obtained from The Registrar, The Technical College, Sunderland.

North Staffordshire Technical College, Stoke-on-Trent

Principal : E. R. PATRICK, Ph.D., B.Eng., A.M.I.Mech.E., A.M.I.E.E.
Head of Department : R. TEALE, M.A., A.Inst.P.

PHYSICS DEPARTMENT — SESSION 1960-61

SPECIAL COURSES IN APPLIED PHYSICS

It is intended that weekly lecture courses covering the following topics will be given :

The measurement and control of temperature

The production and measurement of high vacuum semiconductors

Ionizing radiations and health hazards

Each course will comprise about ten meetings of 2 hours each

REGULAR COURSES IN APPLIED PHYSICS

The department provides instruction in Physics at Higher National Certificate and equivalent levels to students of the departments of Engineering, Ceramics, Chemistry and Mining. It also provides courses for Ordinary and Higher National Certificates in Applied Physics, for the Graduateship examination of The Institute of Physics and for City and Guilds and other courses in Industrial Instrumentation.

Full details of the above and other courses offered may be obtained from the Head of Department

COLLEGE OF TECHNOLOGY, OXFORD

SCHOOL OF SCIENCE

SESSION 1960-61

FULL-TIME COURSES

B.Sc. (London General External) in Mathematics and Physics, Physics and Chemistry, Botany and Zoology.

Grad.Inst.P. One year post pass degree or H.N.C.

G.C.E. "A" level in Pure Mathematics, Applied Mathematics, Physics, Chemistry, Botany, Zoology, Geology.

PART-TIME COURSES

O.N.C. and H.N.C. Applied Physics

Grad.Inst.P.

G.C.E. "A" level.

Final Examination of the Association of Incorporated Statisticians (evening course)

Further information from The Registrar, College of Technology, Headington Road, Oxford.

BOROUGH POLYTECHNIC

BOROUGH ROAD, S.E.1

Special Postgraduate Courses in Applied Physics

SESSION 1960/61

Lecture Courses, by specialist lecturers, will be held weekly in the following subjects :—

Nuclear Physics for Nuclear Power
Nuclear Power Technology
Nucleonic Circuitry (Electronic Equipment used in Nuclear Physics)
Nuclear Particle Techniques (Nuclear Instruments and isotope applications)
Reactor Instrumentation and Control
Digital Circuit Techniques
Principles and Applications of Transistors
Principles of Pulse Techniques

Laboratory Courses will also be held in the following subjects :

Nucleonic Techniques and Measurements
(Full-time and part-time)

Nuclear Power Technology
(Part-time)

Pulse Circuits and Techniques
(Part-time)

Design, Use and Maintenance of Electronic Equipment used in Nuclear Physics
(Full-time)

Leaflets giving full particulars of these and of other postgraduate courses can be obtained from the Secretary, Borough Polytechnic, Borough Road, London, S.E.1.

Northampton College of Advanced Technology, London

Department of Applied Physics

SESSION 1960-61

Applied Physics Sandwich Course for the Diploma in Technology

This course, established in 1956, leads to the award of the Diploma in Technology and has been approved by The Institute of Physics as carrying exemption from the Graduateship examination. The duration of the course is four years; in each year the student spends an average of six months full-time study at the College and the remainder in practical training in industry. The College appoints tutors to the students who supervise their progress while in College, visit them in their industrial periods and act as liaison officers with the firms.

The scheme is a co-operative enterprise to which the College and the Industrial Organizations contribute equally. It provides a training in theoretical and experimental physics, with particular emphasis on the application of physics in industry.

The subjects in the course consist of Physics, Applied Physics and Mathematics together with certain ancillary subjects. For the Applied Physics of the final year the student selects two subjects in which to specialize ; he also undertakes a project related to his particular field of study. Throughout the course, a proportion of the time is spent in non-technical studies. All students become members of the Students' Union Society and are expected to share in its many activities.

The entry requirements are at least two appropriate "A" level G.C.E. subjects and three "O" level subjects including English, or a good O.N.C. in either Applied Physics or Electrical Engineering. The course is open to either Works-based or College-based students. State Scholarships and Local Education Authority Awards may be held by students attending the course.

Two courses are conducted each year. The First Year courses starting in 1960-61 will be as follows:—

(1) Thursday, September 1st, 1960, to Thursday, February 9th, 1961.

(2) Tuesday. February 14th, 1961, to Friday, July 28th, 1961.

POSTGRADUATES COURSES

FULL-TIME

THE PHYSICS OF SEMICONDUCTORS

This course of one session duration, leads to the award of the Diploma of Northampton College, London.

PART-TIME

The following courses will be conducted :

SEMICONDUCTORS
AN INTRODUCTION TO NUCLEAR POWER
OPTICAL INSTRUMENTS
HIGH VACUUM TECHNIQUES
ELECTRON MICROSCOPY
DIELECTRIC MATERIALS

RESEARCH

Facilities are available for research in various branches of Applied Physics for students wishing to obtain higher qualifications, including Membership of the College of Technologists (M.C.T.).

Further details may be obtained from the Head of the Applied Physics Department, Northampton College, St. John Street, London, E.C.1.

CITY OF PORTSMOUTH COLLEGE OF TECHNOLOGY

Principal : DR. W. DAVEY, F.R.I.C.

DEPARTMENT OF MATHEMATICS AND PHYSICS
SESSION 1960-61

FULL-TIME COURSES :
University of London External General B.Sc.
General Certificate of Education at "A" Level.
University of London External Special B.Sc. in Mathematics.

PART-TIME and EVENING COURSES :
University of London External Special B.Sc. in Mathematics and Physics.

University of London External General B.Sc.
National Certificate in Applied Physics.
General Certificate of Education at "A" Level.

Session opens on the 19th September, 1960.

Further particulars and forms of application may be obtained from the Registrar.

SOUTH EAST LONDON TECHNICAL COLLEGE

LEWISHAM WAY, S.E.4

SESSION 1960-61

Courses in Applied Physics

Part-time courses leading to Graduateship of The Institute of Physics

Evening and part-time day courses for Higher National and Ordinary National Certificate in Applied Physics.

2 year, six months "sandwich" course in telecommunications.

Special evening courses on nuclear engineering, electronic switching, non-linear servo control systems, optical instrument design, high voltage engineering, advanced electrical circuit theory, vector analysis and electromagnetic theory.

Further details from the Head of the Department of Electrical Engineering and Applied Physics.

NOTTINGHAM and DISTRICT TECHNICAL COLLEGE

BURTON STREET, NOTTINGHAM

Principal :
D. A. R. CLARK,
M.Sc.(Tech.), M.I.Mech.E.,
M.B.I.M., A.F.R.Ae.S.

Full time Course for B.Sc. (General)
London University (External)

A three-year full-time course for this degree is provided in Chemistry, Botany, Zoology, Physics and Mathematics.

Fees: *Under 18 - Nil.*
Over 18 - £21 per annum.

Application forms may be obtained from the
Principal, Nottingham and District Technical College, Burton Street, Nottingham.

BOURNEMOUTH MUNICIPAL COLLEGE OF TECHNOLOGY AND COMMERCE

Part-time day and evening courses are offered for the following qualifications :—

ORDINARY AND HIGHER NATIONAL CERTIFICATES IN APPLIED PHYSICS
specializing in either Electronics, Vacuum Technology, Instrumentation and Physical Methods of Analysis or Reactor Physics and ancillary subjects.

GRADUATESHIP OF THE INSTITUTE OF PHYSICS

Full-time and part-time courses are also available for:

B.Sc. (GENERAL)
NEW REGULATIONS

Full details may be obtained from the Head of the Science Department, Dr. C. J. Cooper, B.Sc., A.R.C.S., F.R.I.C., Bournemouth Municipal College of Technology and Commerce, Lansdowne, Bournemouth.

THE WELSH COLLEGE OF ADVANCED TECHNOLOGY
CATHAYS PARK, CARDIFF

Principal : A. HARVEY, Ph.D., B.Sc., F.Inst.P.

DIPLOMA IN TECHNOLOGY IN APPLIED PHYSICS

A four-year Sandwich course in Applied Physics leading to the Diploma in Technology (Dip.Tech.) will commence in September, 1960.

This Diploma will be a qualification satisfying completely the academic requirements for Graduateship and corporate membership of The Institute of Physics. Students may be "Works" or "College" based, and will spend alternate six-monthly periods in College and Industry.

Normal requirements for admission to the course will be success at G.C.E. "A" level, or O.N.C., at a high standard, in Applied Physics or Electrical Engineering. Details of the course may be obtained from, and application should be made to, the Principal.

ROBERT E. PRESSWOOD,
Clerk to the Governors.

City Hall, Cardiff.

COUNTY BOROUGH OF BRIGHTON EDUCATION COMMITTEE

BRIGHTON TECHNICAL COLLEGE

Principal - - - G. E. WATTS, M.A., Ph.D.(Cantab), B.Sc.(Lond.), F.R.I.C.
Head of Physics Department - N. PENTLAND, M.Sc., Ph.D.(Lond.), F.Inst.P.

The following courses will be in operation during the session 1960/61 :—

(*a*) **4-year Sandwich Diploma in Technology Course in Applied Physics—**
Two streams each year with college sessions of the course commencing in September and January. Students may be either "industry" or "college" based. Successful students will be given exemption from the academic requirements for Graduateship of The Institute of Physics.

(*b*) **3-year Full-time College Diploma Course in Applied Physics—**
September entry. Successful students will be given exemption from the academic requirements for Graduateship of The Institute of Physics.

(*c*) **Ordinary and Higher National Certificate Courses in Applied Physics,**
including Conversion Year between G.C.E. Advanced Level and Higher National Certificate.

(*d*) **Graduateship of The Institute of Physics—**
a 2-year day release course for holders of the Higher National Certificate in Applied Physics.

A copy of the College Calendar and an enrolment form may be obtained from the Registrar. Additional information on application to the Head of the Physics Department, Brighton Technical College, Brighton, 7.

W. G. STONE, M.A.,
Director of Education.

College of Advanced Technology

GOSTA GREEN, BIRMINGHAM, 4

Telephone : ASTon Cross 3611

Principal : P. R. F. VENABLES, Ph.D., B.Sc., F.R.I.C.

DEPARTMENT OF PHYSICS

Head of Department : J. H. DAVIS, Ph.D., B.Sc., F.Inst.P., A.M.I.E.E.

SESSION 1960-61

FULL-TIME COURSES	B.Sc. General Degree (London External) B.Sc. Special Degree (London External) Diploma in Technology in Applied Physics (Sandwich course) Ophthalmic Optics Nuclear Power Technology (six weeks course)
PART-TIME DAY AND EVENING COURSES	Higher National Certificate in Applied Physics Graduateship of The Institute of Physics B.Sc. General (London External) B.Sc. Special (London External) Associateship of the College
EVENING COURSES	Postgraduate short courses in :— Semiconductors, Transistors, Electronics, Fluctuations, Vacuum Technique, Acoustics and Noise Measurement, X-rays, Ophthalmic Optics, Nuclear Power Technology, Industrial Applications of Radioactive Materials, Directionality (with Metallurgy Dept.) Opportunities for Research also exist.

SESSION OPENS ON SEPTEMBER 26th, 1960

Further particulars of all these courses and mode of application may be obtained from the Head of the Department of Physics

BOROUGH POLYTECHNIC

BOROUGH ROAD, S.E.1

The following undergraduate courses in Physics are available :—

Sandwich Course (four years)
leading to the
DIPLOMA IN TECHNOLOGY IN APPLIED PHYSICS
(*with specialization in Applied Nuclear Physics*)

Part-time (Day or Evening) Courses
leading to the
GRADUATESHIP OF THE INSTITUTE OF PHYSICS

Part-time (Day or Evening) Courses
in preparation for
SCIENCE DEGREES
(*External*)
of the University of London

For Prospectus of (*a*) Full-time and Sandwich courses or (*b*) Part-time courses, apply to The Secretary, Borough Polytechnic, Borough Road, London, S.E.1

SOUTH-WEST ESSEX TECHNICAL COLLEGE

Science Department

Principal : H. LOWERY, M.Ed., Ph.D., D.Sc., F.Inst.P.
Head of the Science Department : S. LEWIN, M.Sc., Ph.D.

Full-time Courses :

A three-year course for the External B.Sc. General (Revised Regulations) of London University.

Research for Higher Degrees. Considerable facilities are available in Electronics, High Vacuum Techniques, Optics, and X-ray Measurements.

Part-time Day and Evening Courses :

A four-year course for the External B.Sc. General Degree.

Laboratory Technician courses.

Graduateship of The Institute of Physics.

Research for Higher Degrees.

Leaflets giving full particulars of these and of other postgraduate courses may be obtained from the Head of the Science Department.

MIDDLESEX COUNTY COUNCIL EDUCATION COMMITTEE

BRUNEL COLLEGE OF TECHNOLOGY

WOODLANDS AVENUE, ACTON, W.3

Principal : J. TOPPING, M.Sc., Ph.D., D.I.C., F.Inst.P.

DEPARTMENT OF PHYSICS

Head of Department: C. A. HOGARTH, B.Sc., Ph.D., F.Inst.P.

The following courses are among those to be held during the session 1960/61. Autumn Term begins September 19th, 1960.

Diploma in Technology in Applied Physics

A four-year Sandwich course commencing in January, 1961. Specialist subjects in the course include Nuclear Technology, X-ray Crystallography, Electronics, High Vacuum Technology, Electrical and Magnetic Properties of Solids, Applied Acoustics.

B.Sc.(General) Degree of the University of London.

The next part-time course begins in September, 1960, and extends over four years.

Higher National Certificate in Applied Physics

Subjects include Electronics, High Vacuum Technology, Applied Acoustics. New course begins in September, 1960, and is held on a day-release basis.

Graduateship of The Institute of Physics

A day-release course for holders of the Higher National Certificate in Applied Physics. Commencing in September, 1960, and extending over two years.

Evening courses to postgraduate standard are offered in the following subjects : Non-destructive Testing, X-ray Crystallography, Nuclear Reactor Physics, Semiconductors, Health Physics.

Full details of courses and enrolment forms obtainable from the Registrar (ACOrn 6661).

BRADFORD INSTITUTE OF TECHNOLOGY

Principal : E. G. EDWARDS, B.Sc., Ph.D., F.R.I.C.

DEPARTMENT OF PHYSICS

Head of Department: D. L. SMARE, B.Sc., M.Sc.(Tech.), Ph.D., F.Inst.P.

SESSION 1960-61

Full-time courses of study will be available in the following subjects :

Applied Physics. A four-year sandwich course leading to the qualification of Dip.Tech. Students will spend alternate periods of six months in College and in industry and may be either " industry " or " College " based.

B.Sc. London External. Three-year courses for the General Degree (two final subjects selected from Physics, Chemistry, Mathematics, Botany or Zoology).

Nuclear Reactor Technology (in collaboration with the Department of Electrical Engineering). Six weeks duration : the next course will begin on August 29th and others will be arranged later in the session.

Ophthalmic Optics. A three-year course leading to a recognized professional qualification.

Special Short Courses are being arranged in Nuclear Physics, Physics of the Solid State, Illumination, X-ray and γ-ray Radiography, Optical measuring devices, Ophthalmic Optics.

Further details and forms of application for these courses may be obtained from the Head of Department.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF PHYSICS

Session 1960-61

FULL-TIME AND PART-TIME COURSES

POSTGRADUATE COURSES

The following courses begin on 3rd October, 1960 :

ACOUSTICS AND VIBRATION PHYSICS
NUCLEAR PHYSICS
PHYSICAL ELECTRONICS
SEMICONDUCTORS
OPTICS
ELECTRONIC CIRCUITS

New courses include

RADIATION PHYSICS and METHODS OF MODERN MICROSCOPY

Suitably qualified students may register as M.Sc. Internal students of the University of London.

INTERNAL DEGREE COURSES (Full-time and " Sandwich ")

The following courses begin on 26th September, 1960 :

FULL-TIME AND " SANDWICH " COURSES FOR SPECIAL DEGREE

FULL-TIME COURSES FOR GENERAL DEGREE

For students engaged in industry the *Sandwich* course has been planned as an alternative part-time course in which students attend for two terms full-time and one term part-time in each of four sessions. Each course is an Honours course and students study as Internal students of the University of London.

Details and application forms may be obtained from :
The Secretary, Physics Dept., Chelsea College of Science and Technology, London, S.W.3. FLAxman 5747.

CTIY OF LEICESTER EDUCATION COMMITTEE

LEICESTER COLLEGE OF TECHNOLOGY AND COMMERCE

SCHOOL OF PHYSICS

Part-time Day and Evening Courses :—

Ordinary National Certificate in Applied Physics

Higher National Certificate in Applied Physics

Graduateship of The Institute of Physics

B.Sc.(General) New Regulations

Electronic and Control Technology Diploma

Microwave Physics

DEPARTMENT OF MATHEMATICS

Part-time Day Courses :—

Computing (to G.E.C. "A" Level)

Industrial Mathematics (three-year post "A" Level)

Statistics (to A.I.S. Final standard)

Evening Courses :—

Matrices

Tensor Calculus

Mathematical Statistics

Partial Differential Equations

Programming for Electronic Computers

Short Residential Courses :—

Linear Programming

Quality Control

Industrial Sampling

Industrial Experimentation

BRISTOL COLLEGE OF SCIENCE AND TECHNOLOGY

Part-time day and evening courses are offered for the following qualifications :

HIGHER NATIONAL CERTIFICATE IN APPLIED PHYSICS

GRADUATESHIP OF THE INSTITUTE OF PHYSICS

B.Sc. (GENERAL) NEW REGULATIONS

Postgraduate short courses on specialized Physics topics are held frequently.

Further details may be obtained from the Registrar, College of Science and Technology, Ashley Down, Bristol, 7

WEST HAM COLLEGE OF TECHNOLOGY

ROMFORD ROAD, LONDON, E.15

Internal B.Sc. Degree University of London

Full-time and part-time courses available

Higher National Certificate in Applied Physics

Part-time courses available

Postgraduate Course Recent Advances in Physics

A course of twelve lectures commences on Thursday, September 29th, at 7 p.m.

Research

Postgraduate Research under Recognized Teachers of the University of London may be pursued during the day or evening for the Internal Degrees of M.Sc. and Ph.D. by suitably qualified Graduates of most Universities.

For particulars of above and other short postgraduate courses apply to the Principal.

KINGSTON-UPON-HULL COLLEGE OF TECHNOLOGY

Principal :
EMLYN JONES, M.Sc., F.R.I.C.

DEPARTMENT OF PHYSICS

A full-time three-year course for the external B.Sc. general degree of London University.

Part-time short courses in:

Radioisotope techniques

Electronics

High Vacuum Technology (1961)

Microscopy (1961)

Prospectus and further details of courses from the Head of the Physics Department, College of Technology, Park Street, Kingston-upon-Hull.

ADVANCED ENGINEERING TRAINING

The College of Aeronautics

offers courses at post-graduate level in

AERONAUTICAL SCIENCE AND TECHNOLOGY · FLUID MECHANICS
THE PHYSICS AND MECHANICS OF STRUCTURAL MATERIALS
CONTROL ENGINEERING
(Process Control and Flight)
HIGH PRECISION ENGINEERING
OPERATIONAL RESEARCH · GUIDED MISSILES

Candidates for admission should be university graduates in engineering, science or mathematics or have attained that standard of education through engineering training and experience. The successful completion of a course leads to the award of the College Diploma.

Information from the Warden
The College of Aeronautics, Cranfield, Bletchley, Bucks.

The Advanced School of Automobile Engineering

offers courses at post-graduate level in

AUTOMOBILE ENGINEERING

Information can be obtained from the Administrator
The Advanced School of Automobile Engineering, Cranfield, Bletchley, Bucks.

ROYAL TECHNICAL COLLEGE, SALFORD

DEPARTMENT OF PURE AND APPLIED PHYSICS
SESSION 1960/61

Acting Head of Department : Miss B. Yates, B.Sc., A.Inst.P.

FULL-TIME COURSES	B.Sc. General (London External). Diploma in Technology in Applied Physics — 4-year Sandwich Course. Certificate Course in Radiological Health and Safety. Nuclear Power Technology — short courses : Aug. 29th to Oct. 7th and Oct. 24th to Dec. 16th.
PART-TIME DAY AND EVENING COURSES	Special and General B.Sc., London (External). Higher National Certificate. Grad.Inst.P. (Physics I, II, III, More Advanced Physics, Electronics, X-rays, Nuclear Instruments).
POSTGRADUATE COURSE	Detection and Measurement Instrumentation for Nuclear Radiation, commencing Oct. 3rd.
RESEARCH	Details of facilities for research and projects being studied will be sent on request.

Full details may be obtained from the Registrar

MIDDLESEX COUNTY COUNCIL EDUCATION COMMITTEE

BRUNEL COLLEGE OF TECHNOLOGY

WOODLANDS AVENUE, ACTON, W.3

Principal : J. TOPPING, M.Sc., Ph.D., D.I.C., F.Inst.P.

DEPARTMENT OF MATHEMATICS

Diploma in Technology in Mathematics

A four-year Sandwich course commencing in September, 1960. Modern Applied Mathematics, Practical Computation and Statistics are supported by relevant sections of Pure Mathematics, Physics and Electronics. The course is open to employees of firms willing to support them, and also to school leavers. State Scholarships and Local Education Awards may be held by students attending this course.

Numerical Analysis and Statistics

This part-time day and evening course is intended for those employed in Government Establishments and Industry and is in two parts. Part I (Wednesdays) is taken during the first year. Part II (Thursdays) is taken during the second and third years. A College Certificate is awarded at the end of each part.

Associateship of Incorporated Statisticians

A one-year course leading to the Intermediate Examination of the A.I.S. will commence on September 22 (Thursday evenings) from 6.30 to 9.30.

Candidates must have obtained Pure Mathematics at "A" Level.

Evening Postgraduate Courses

Mathematics and Techniques of Circuit Analysis.

Complex Variable, Laplace Transformation and Non-Linear Differential Equations.

Advanced Mathematical Programming.

Vector Analysis.

Differential Equations.

Numerical Solution of Partial Differential Equations.

Numerical Analysis for Automatic Computers based on Chebyshev polynomials.

Full details of courses and enrolment forms obtainable from the Registrar (ACOrn 6661).

WOOLWICH POLYTECHNIC

Principal :

HAROLD HEYWOOD, D.Sc.Eng., Ph.D., A.C.G.I., Wh.Sch., M.I.Mech.E., M.I.Chem.E.

DEPARTMENT OF PHYSICS AND TELECOMMUNICATIONS

Full-time and part-time day courses are offered for the

B.Sc. SPECIAL DEGREE IN PHYSICS (INTERNAL)

and the

B.Sc. GENERAL DEGREE (INTERNAL)

of the University of London

Facilities are available for experimental research for the M.Sc. and the Ph.D. degrees.

One-Year Preliminary University Entrance courses are provided for students who have not yet qualified to enter final degree courses.

Requests for information and applications for admission should be addressed to the Secretary, Woolwich Polytechnic, London, S.E.18.

NORTHERN POLYTECHNIC

HOLLOWAY, N.7 **NORth 1686**

Department of Physics — Session 1960-61

DEGREE COURSES IN PHYSICS for Internal Degrees of The University of London.

Full-time and Part-time Courses leading to
B.Sc. Special Physics
B.Sc. General
M.Sc. by examination.
Research leading to Ph.D., and M.Sc.

Sandwich Course leading to B.Sc. Special Physics.

Advanced Part-time Courses in
Electronic and Microwave Physics
Electrical Discharges in Gases
Solid State Physics

Students with suitable degrees in Physics, following one of these courses, accompanied by practical work, can proceed to the M.Sc. degree of the University of London.
The lectures are not confined to such students, but are open to any working in appropriate fields.

COURSES IN APPLIED PHYSICS

Diploma Course in the Physics and Technology of Electronics

Sandwich Course leading to the Diploma in Technology (Dip. Tech.) and Graduateship of The Institute of Physics (Grad.Inst.P.)

Part-time Course leading to Graduateship of The Institute of Physics

National Certificates in Applied Physics

Ordinary National Certificate. Course available to Students of 16 and over.

Higher National Certificate. Course available to students with O.N.C. or with suitable passes in G.C.E.

Students taking the H.N.C. Course at the Northern Polytechnic can proceed to complete the College Diploma Course and qualify in this way for Grad.Inst.P.

Inquiries should be addressed to The Head of the Department of Physics.

DERBY AND DISTRICT COLLEGE OF TECHNOLOGY

Principal:
T. HEAP, Ph.D., M.Sc., F.R.I.C., A.M.B.I.M.

PHYSICS DEPARTMENT

Head of Department:
G. SIM, M.Sc., A.Inst.P.

FULL-TIME AND PART-TIME COURSES LEADING TO THE UNIVERSITY OF LONDON EXTERNAL B.Sc. (GENERAL) DEGREE

PART-TIME COURSES FOR ORDINARY AND HIGHER NATIONAL CERTIFICATES IN APPLIED PHYSICS

LABORATORY AND TUTORIAL CLASSES FOR THE INSTITUTE OF PHYSICS GRADUATESHIP EXAMINATIONS

FACILITIES FOR RESEARCH

For further details of these and other courses apply to the Head of the

PHYSICS DEPARTMENT, DERBY AND DISTRICT COLLEGE OF TECHNOLOGY, KEDLESTON ROAD, DERBY.

CROYDON TECHNICAL COLLEGE

Principal:
D. A. GREEN, M.B.E., B.Sc., M.Ed.

DEPARTMENT OF SCIENCE

Part-time day and evening courses are offered for the following qualifications :–

B.Sc. (General):- New Regulations

Graduateship of The Institute of Physics

Higher National Cert. in Applied Physics

Ordinary National Cert. in Applied Physics

Further particulars and information may be obtained from the Head of the Science Department, Croydon Technical College, Fairfield, Croydon.

KINGSTON TECHNICAL COLLEGE

Fassett Road
Kingston-on-Thames

Department of Physics and Mathematics

offers full-time and part-time courses for B.Sc. General Degree, Graduateship of The Institute of Physics, Ordinary and Higher National Certificates in Applied Physics, Postgraduate Courses in Nuclear Physics, Transistor Circuitry, Electronics, Laplace Transforms

Further particulars from the Head of Department

BATTERSEA COLLEGE OF TECHNOLOGY
LONDON, S.W.11

Department of Physics and Section of Crystallography

Undergraduate Courses

1. B.Sc. Special (University of London Internal).
   Full-time and part-time courses.
2. Diploma in Technology. This course is arranged on a Thick Sandwich basis suitable for both College and Industry based students. It consists of three years in College with an industrial year between the second and third College years. It is recognized for exemption from the Graduateship of The Institute of Physics.

Postgraduate Courses

1. Microwave Physics.
2. X-ray Crystallography.

These courses consist of lectures and practical work and can be taken either full-time or part-time. Suitably qualified students may proceed to the M.Sc.(London Internal) by dissertation and/or examination or to the Postgraduate Diploma of the College. *The Department of Scientific and Industrial Research has accepted these courses as suitable for the tenure of its Advanced Course Studentships.*

3. Radiation Physics and Radiological Protection.

This is a part-time course leading to the Diploma of the College.

4. Radiological Protection.

This is an evening course leading to the Certificate of the College.

5. Rheological Techniques (evening course).

Research

There are vacancies for students to do research leading to the M.Sc. or Ph.D. (London Internal) in the following fields :

1. Microwave Physics
2. Metal Physics
3. Rheology
4. Theoretical Nuclear Physics
5. Crystallography

A small number of Research Assistantships is available for suitably qualified students.

All enquiries should be addressed to
L. R. B. Elton, Ph.D., F.Inst.P., Head of the Physics Department.

THE POLYTECHNIC
309 Regent Street, W.1

DEPARTMENT OF MATHEMATICS AND PHYSICS

Full-time and part-time day courses are available for B.Sc. General in Pure Mathematics, Physics and Chemistry (Part I), Physics and Mathematics or Chemistry (Part II), B.Sc. Special in Physics and Grad. Inst.P.

Evening courses are offered in B.Sc. General, Statistics, Electronics, and Postgraduate Mathematics.

Prospectuses may be obtained from the Director of Education.

SIR JOHN CASS COLLEGE
Jewry Street, Aldgate, E.C.3.

The College provides Full-time and Part-time (Day Release) Courses for the Internal Special Degree in Physics and the B.Sc. (General) Degree of the University of London.

There are also courses for the Graduateship Examination of the Institute and special courses of lectures on various topics including Electron Diffraction, Theoretical Physics and Experimental Techniques in Physics.

Research work for a higher degree in Physics may also be undertaken, full-time or part-time.

Prospectus, application forms and details of special courses may be obtained from the Secretary.

NORWOOD TECHNICAL COLLEGE
London, S.E.27

Department of Physics and Mathematics

B.Sc. General/Electronics
4-Year Sandwich Course

Students spend Autumn and Spring Terms in full-time study and the remainder of each year in industrial employment. Open to employees of firms willing to sponsor them and also to school leavers. Entrance standard: 2 "A" Level and 3 "O" Level passes.

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THE INSTITUTE OF PHYSICS

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What Employers Look For in Graduate Physicists

H. V. WALTERS

B.Sc., Ph.D., F.Inst.P.

Appointments Officer, University of Durham

One of my academic colleagues, not a physicist, when agreeing with me that it is important to distinguish between what employers say they want and what they want, pointed out that a further distinction is necessary, between what the employer wants and what he needs. The force of this necessity is in no way diminished by the fact that this colleague's picture of the sort of recruit employers need corresponded closely to the sort of person he thought his department produced.

A further set of distinctions has to be made in order to treat this topic in a reasonably systematic way. There are the qualities that employers look for in recruits, the qualities looked for in graduate recruits in particular, in graduates in the sciences, and in physics graduates specifically. Then there are certain qualities which all employers are looking for in physics graduates whatever sort of job they are going to do, both now and later, other qualities which are necessary to some jobs and not to others, and qualities which some employers more than others look for assiduously.

I can well imagine that, say, an undergraduate reading a statement like this will feel that if, on top of worrying himself silly about getting a degree, he also has to address himself to the cultivation of qualities B, F and H in order to be considered for a job J with Messrs. Q, S, or W, this is more than he bargained for. Of course it is and it is not necessary.

The virtues extolled by municipal dignitaries on school speech days, as determinants of success in those about to enter the " battle of life " need no liturgical incantation —or denial. Honesty, sobriety, the habits of hard work, regular visits to the dry cleaners and the use of soap, nailbrush and towel (though not necessarily razor) are qualities whose absence employers are quick to point out, sometimes as though they were the first to notice. If this all seems obvious, one might ask if it is not so obvious that it escapes attention. Slovenliness in dress and toilet, and a reaction of feigned surprise when caught without a ticket on a train can be put down to preoccupation in a genius and forgiven, but are most damaging to any candidate for a university chair, for example.

Were it not for the law of libel, I could relate some desperate stories about students I have had " on my books " and so, no doubt, could all my brethren in all other universities, Oxford, Cambridge and London not excluded. Perhaps, then, for fear of libel proceedings it may be wise to generalize a little about the specific cases which have come to my notice.

The most common criticism of the modern undergraduate (who probably bears a remarkable resemblance to all his predecessors, though being one of them it is difficult to judge) is lack of enthusiasm for anything, including physics. Employers want a much better reason for an applicant having chosen to read for a degree in physics than that this was the subject in which he got most marks at Advanced level. The same is true, of course, for any subject.

Neither is an employer likely to be impressed by an applicant who can say, without any sense of incongruity or shame, that there is no part of physics with which he has been confronted in his lectures and his reading which has fired his imagination and his curiosity. It is no doubt academic treachery to say so, but I am, and have long been, convinced that too much of the taxpayer's money is swallowed up in research grants for such students who are interested, not in research, but in being classed as research workers, not in beating their brains out on a fiendishly difficult physical problem, but in getting a Ph.D. At least university physics departments are not the worst offenders in this respect and it is probably unnecessary (and more treacherous still) to say which departments really take this biscuit.

A prime essential, then, is real interest in and enthusiasm for something. If that something for a graduate physicist is not physics, some rather searching questions are going to be asked, but they are not in the nature of things unanswerable.

Next in the frequency spectrum of criticisms comes the complaint about " colourless " personality. There seems to be a fairly widespread belief that a degree, and more particularly a degree in something like physics, will somehow compensate for a habitually hangdog appear-

ance, for being tongue-tied in company or for a tendency to blankness of the mind when asked a question. After all, what are such handicaps when set against ability to write a good essay on gamma-ray spectroscopy or to build an amplifier ? The trouble is that life does not consist of writing essays, on gamma-ray spectroscopy or any other topic, and graduates are not normally expected, for more than a very short time at any rate, to build amplifiers.

When an employer takes on a graduate, physicist, historian, economist or what you will, he is investing, he hopes, in someone who probably will not earn his keep for a couple of years or so but who will then pay dividends over a long period in the shape of fertile ideas, sound policy thinking, and very probably ability to " run " things—a section of the research effort, a development project, a specialized bit of production, or a technical sales and service department—which he knows extremely little about when he first joins. Faint heart not only never won fair lady, but also it never " got things done " and it is ability to get things done quite as much as to do things which matters when an employer is sizing up a graduate.

Rightly or wrongly, employers expect graduates to have more ideas than they will have time to work out in detail and/or for which they will need more than one pair of hands to do the necessary experimental work. To put it yet another way, it is not just ability that counts, it is *effective* ability ; and by effective I mean effective in a human situation which is where most human beings earn their bread and butter.

Lest it be suspected that I am suggesting that there is an absence of correlation, or even a negative correlation between academic ability and effective ability in a job, let me be quite specific about that.

On two occasions, I believe, the degree classes of Fellows of the Royal Society have been the subject of enquiry. Many of them were found to have first class honours degrees ; a handful at the most had thirds. (This may not prove all that much, though I never heard that Sir Ronald Fisher entered the lists to point out the pitfalls in arguing from this observation as he did, for example, over similar pitfalls in interpreting the correlation between smoking habits and the incidence of lung cancer.)

By contrast, I am fairly confident that a survey of the degree classes of successful traders in war surplus stocks, of car dealers and of take-over bidders would fail to produce any correlations at all, probably because one of the correlates was absent, expecially if one imposed the restriction that they must be millionaires.

These extreme examples were selected to illustrate the point that the more scholarship *of an academic kind* is involved in an occupation, the closer the correlation of academic and effective performance. It should, of course, be pointed out that being a Fellow of the Royal Society is not employment, though becoming one may be a job. Being a car dealer is, even for the self-employed.

One of the commonest misconceptions among university students (commoner still among their non-graduate parents, aunts and uncles) is that a degree is a licence to practice. Members of the Institute know better, of course. One characteristic that employers look for is, therefore, an appreciation on the part of the graduate that he has to learn a trade, and this cannot be too strongly emphasized. The raw graduate may be right up to the minute on parts of his subject which no one among the staff he is joining has looked at for years, but they know their business and he doesn't. It is better if he appreciates this fact.

Of course, it is possible to learn two trades at the university. Unlike craft apprenticeships, the acquisition of these two skills—teaching and " research "—is made the subject of examination, and not all graduates pass. Other skills, such as designing equipment, process development, production " trouble-shooting " or technical salesmanship are not formally examined and by and large are less formally taught, but there are ways and means of assessing capacity in these skills. The graduate's first *real* job will depend on the way he surmounts his second hurdle, professional training, if we count his final degree examinations as the first hurdle. The sort of training he can get will depend, not only on the sort of degree he gets, but whether he looks as though he can bend (and would be interested in bending) the talent reflected by his degree performance to the sort of problem the employer is up against.

It is fairly commonly realized, though possibly not commonly enough, that ability to co-operate with all sorts and conditions of people is an asset to a recruit to industry or business. It may not be realized at all widely how great an asset this ability is in *any* job. It is commonly said that professorial selection committees are too easily impressed by a long list of publications and that universities enquire too little into the ability of a candidate for a lectureship to lecture, but there is the ever-present consideration that the new man appointed will have to be endured at lunch and may easily be elected to some of the same committees as the selectors.

Now clearly all this is over-simplified and over-generalized. A genius may, without serious loss to himself, his dependents or the world at large, be a tadpole (big head and the rest rudimentary) but one really needs to be a genius to afford the luxury of a vestigial personality, or an exceptionally angular one. If all one has is a first class brain, such impedimenta are nothing but a damned nuisance.

I can think of graduates, in science more particularly (and this may be because I know more of them), whose personalities could be described as spare and angular, who feel bitter about the comparatively greater success enjoyed by smoother, glibber, more sociable types. Even so, we surely do not need to fear unnecessarily the diagnosis of " Organization Man," the " well-rounded," conforming, not-too-ambitious, proud-husband-and-father type that American business is said to be begetting. One can get things done by being the sort of person other people like and will therefore do things for. One can get them done by commanding respect—for ability or judgment or knowledge or experience or simple integrity—but without incurring affection. How enviable is the man who can command both affection and respect. I somehow feel that Organization Man doesn't merit much of either.

There are, of course, jobs where imagination, intellectual curiosity and high effective ability are not wanted, but then employers do not think of seeking graduates to fill them. What is more, even if the graduate seeks them out himself, and there are plenty advertised in the local papers, the employer will be most reluctant to consider him because he feels he should not offer such a job to a man who has contrived to fool the people who admit students to universities. He suspects that the graduate will almost certainly be too intelligent for the job, that he is possibly a bit psychologically odd and, very likely indeed, that he will become dissatisfied and a trouble-maker.

For this reason, I believe that often the student who gets a poor degree and seems to have been fully occupied in getting it, would have been better advised not to have come to a university at all. Not always. Something may have happened to him and he may be a more worthwhile person than he was or would have become had he pursued some other course, but it is always a hard and bitter struggle to persuade an employer that this might be so.

Another common complaint from employers is that graduates, and even more people with Ph.D.s, expect the world to owe them a living, doing the kind of academic things they have been doing as students. In a way, some employers seem to me inconsistent over this. They say in one context that they want recruits who will be prepared to learn entirely new techniques and to work in quite different ways from any they have been accustomed to, but when they have a vacancy to fill, they always want a " ready-made " recruit to fill it. For some reason, employers of biologists are more inconsistent in this respect than employers of physical scientists, but it does provide a dilemma for the young physicist. Should he get some postgraduate academic training before taking up employment and, if he does, will he be able to widen his horizons and add to his armoury of techniques later on ? Most employers would answer the second half of that question with an emphatic " Yes, of course," but it is in fact sometimes " No " and hardly ever " of course."

This seems to me a real danger for the man entering a research department. Far less thought seems, in general, to be given to the future of research workers—what in other fields would be called their " career development "—than is given to the grooming of graduates in manufacturing, sales and the various other staff jobs (accountancy, legal, transport, personnel, buying, etc.) in industry. My guess is that, if one could question the staffs of those large firms who have statistically significant numbers of research staff, one would find a considerably higher proportion of them who feel disgruntled, aimless and in a dead end, than one would find anywhere else within the organization.

Now a very wise friend of mine once said that there are no such things as dead-end jobs, only dead-end people. This aphorism crystallized my own thoughts on the matter. Perhaps it is that research workers tend to be dead-end people but, even if this is true, it cannot be the whole explanation. Fortunately the situation in this respect seems to be improving all the time. In other words employers are more and more asking the question " What will this man be doing after 5, 10, 20 years ? " as well as " Can he, with a bit of training, do the job I want done now ? "

The important thing about this trend is that it is not only in the employer's interest, but in the potential employee's as well. It may not be obviously so. The graduate who, in the bad old days, got a job, might be turned down for it now. But the bad old days are continuous with the present day and the man who would not have got the job were he applying to-day is the disgruntled, aimless, dead - end, much - passed - over recruit of yesteryear. Nobody can think what to do with him, unless (the private thoughts run) he sees the light and goes into teaching, or gets a job having a grander-sounding title with an employer in a smaller way of business.

To what extent do employers expect graduate recruits to know specific items of physics ? As a general rule, it is the recruiters for the engineering industry who seem most concerned about the exact content of undergraduate courses. " How much treatment of electronics is there in the course ? " is a common enquiry especially from the small and medium-sized firms. At least in this I think that employers in this country are considerably more sensible than in the U.S.A. and Canada, where recruiters appear to want to draw quite unwarrantable conclusions from and impossibly fine distinctions between degree syllabuses.

In other industries than engineering manufacturing, for example in chemicals, oil and metals, and in the Scientific Civil Service and the Research Associations the question is not so much " What physics does this person know ? " as " Can this person think as a physicist ? " Since I have forgotten pretty well all the examination physics I ever knew, but like to think that I retain at least a hazy idea of physical principles, I approve of this approach. This is not to say that I prefer the chemical industry's approach to graduate recruitment *in toto*.

There is no doubt that the employers who are most dazzled by first class honours degrees and Ph.D.s are the universities who award them (which is odd, when you come to think), but the chemical industry is a strong runner-up, neck and neck with the Civil Service. I know that it may be immediately retorted that, failing a better criterion with which to judge an unknown candidate for a job, his class of degree is not a bad guide ; that provision is made for sorting out mistakes in allocating a recruit to his first post and so on. This is all true, but once the label of Assistant has been affixed, the gum makes a pretty strong bond. The consequences of this are self-perpetuating. The " grape-vine " gets to work. It becomes part of undergraduate folklore that you won't " get on " in XYZ Ltd. or at ABCDE unless you have a top Second at least, while a Ph.D. will see you home and dry. How comes it then that Messrs. XYZ and the Establishments people at ABCDE take on graduates with lower academic qualifications ? Because there are graduates for whom " getting on " is a remote consideration. The proximate and pressing one is " getting in " somewhere. The employers in question then, very understandably if illogically, turn round and say that, from experience, very few men with poor honours or

general degrees are capable of earning much promotion. I have spent a good deal of effort trying to persuade such employers that *their* experience, though not completely atypical, is automatically biassed in one direction.

There is a moral here. If you are an employer, always ask yourself " What does this reference say ? " at least when it comes from a university departmental source. Boil down the verbiage and see if you are left with anything more than a statement that the candidate got a lower Second, which the Registrar could have told you anyway. In other words, if you ask an academic person for an opinion, you are reasonably likely to get an academic opinion, necessary but not sufficient.

Do big employers and small employers look for different things ? The answer to this is mostly " No." The big employer is not nearly so bothered about recruiting men with narrow interests—he often says he doesn't want any—as he is about getting enough all-rounders, men of good intelligence, wide interests, attractive personalities, staunch characters, energy, initiative, of a practical turn of mind but able to reason about abstract principles, confident and balanced in all their dealings. This is the specification of the only sort of graduate the small employer can employ. When it comes to body-snatching, the twittery Ph.D. goes unmolested and the all-rounder is in danger of being torn limb from limb. There was a suggestion, a little while ago now, that by analogy with the Shrove Tuesday festivities at Westminster School, the best Cambridge all-rounder should be thrown into the University Arms Hotel during the recruiting season, and the employer emerging with the largest piece declared the winner.

More seriously, the question of " practical bent " bears examination. Whether or not it is reasonable and justified, there is a quite common complaint by employers that physicists are impractical. Not all physicists, I hasten to add, as I seem to be inviting brickbats from all around. Perhaps it is the way in which applied mathematics is taught. I am indebted to one of Durham's two Professors of Applied Mathematics for the following example. It is the sort of textbook problem which reads : " Two spheres with centres of gravity at A and B, and each of mass M, rest on a horizontal frictionless plane and are connected by a light, taut, inextensible string. An impulse I is imparted to A in the direction BA. Write down an expression for the velocity of B after the delivery of the impulse." The answer, of course, bears no resemblance to anything that can ever be observed to happen. The question is not a question in applied mathematics. It is a kind of parlour game. Not all applied mathematicians would agree. Some would say that it is a kind of five-finger exercise in the equations of motion in Newtonian mechanics. But prolonged practice in exercises of this kind has a brain-washing effect and leads eventually to " engineering drawings " of things which just cannot be made or equipment which just will not work.

The physicist almost certainly will not have the mathematical equipment to tackle the equations of motion of two slightly aspherical billiard balls of nearly equal masses M_1 and M_2, connected by a non-Hookean string of mass M_3 gripped at each end by rubber bands of masses M_4 and M_5 round the equators of the billiard balls, one ball being struck a slightly glancing blow by a bent billiard cue that needs chalking, on a beer-stained and rather grainy deal table which stands on three (but not always the same three) of its four legs. Even so, I am sure that if he sits and ponders long enough on questions like this, he may in due course be able actually to communicate with people like design engineers and others on the perennial industrial problem : how to make something which doesn't cost the earth and can be sold for money.

If he is not interested in this sort of problem, or thinks it is too sordid and beneath the dignity of a graduate physicist, he had better try and stay inside a university, where commerce, sales and advertising are naughty words, where industry (not explicitly) is for those who " aren't good enough " for university jobs, and teaching is for those who aren't good enough for industry. What, you may ask, about the Civil Service, the Research Associations, the Public Corporations and the hospitals? Respectable, yes—as of course the schools are—and perhaps good for the not quite outstanding man ? No one has actually said that to me in so many words, but sometimes inflections speak louder than words.

Finally, what is the poor lad to do who finds that he is not nearly as interested in physics, when it comes to work of degree standard, as he thought he was going to be ? I know this is advertising, but I can think of nothing more sensible for him to do than to go and talk to the Secretary of his Appointments Board. Certainly in a provincial university, and from what I hear from friends who are graduates of collegiate universities, he will be lucky to find anyone else who will be able or interested enough to help him plot out a new course for his career. And of course I am not saying that the undergraduate or postgraduate student who is making a roaring success of his academic work and " knows where he is going " would be wasting his time by talking to the Appointments Secretary. If nothing else, the sheer passage of time and the badgering that it brings have made us all rather better than we were at knowing what Messrs. X are looking for, and whether Mr. Y has got it.

To sum up, the sort of qualities that employers are looking for cannot be cultivated in cold blood. At the same time, no student who knows in his bones that he has a latent quality or talent, which may have no obvious relevance to his degree subject, need, I firmly believe, have any qualms about giving it a pretty loose rein to develop. There will always be a job—and an interesting and worthwhile job, with prospects—for the graduate physicist who has " got *something*."

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Physics and Painting

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PAINTING, in all schools and periods of time, and under the influence of a variety of aesthetic theories, implies communication between the artist and the viewer. The materials of painting, and the techniques whereby they are applied, may thus be compared with a cybernetic system, some of the elements of which can be discussed in terms of physics. Such an analysis defines the possibilities available to the painter, and the limitations imposed upon him.

In the visual pattern he produces, the artist is clearly concerned with the subjective attributes of colour—hue, saturation, and lightness—but it is exceptional for his approach to be in these terms. More often than not he thinks of the colour and form of the object, and light and shade in the scene. Colour is regarded as an intrinsic attribute of the object to which must be added reflections from the surroundings, rather than as resulting from the reflectance of the surface and the quality of the incident light. These traditional notions of the artist have naturally influenced their techniques : some of the techniques are in fact alternative solutions to this problem of rendering colour and form which must be taken into account when interpreting the results of examining paintings by physical methods. Furthermore, when considering the chromatic and rheological properties of artist's paint, it must be understood that he exploits these qualities for their own sake, as a composer does with the vibration characteristics of the various musical instruments, rather than as materials in a process of reproduction or photography. Various visual perception phenomena are also of paramount importance in all periods, but particularly so to the Post-impressionists, and their successors, who were influenced by the writings of Chevreul, Helmholtz and Ostwald.

ARTISTS' PAINT

In the paint, the three main constituents have each a basic function : the pigment provides the colour ; the medium is first a vehicle and then, by some transformation, a binding material ; the diluent enables the artist to alter the consistency of the paint. (See Fig. 1.)

Substances selected for each function inevitably have other associated properties, some desirable and some which prove restrictive to the artist.

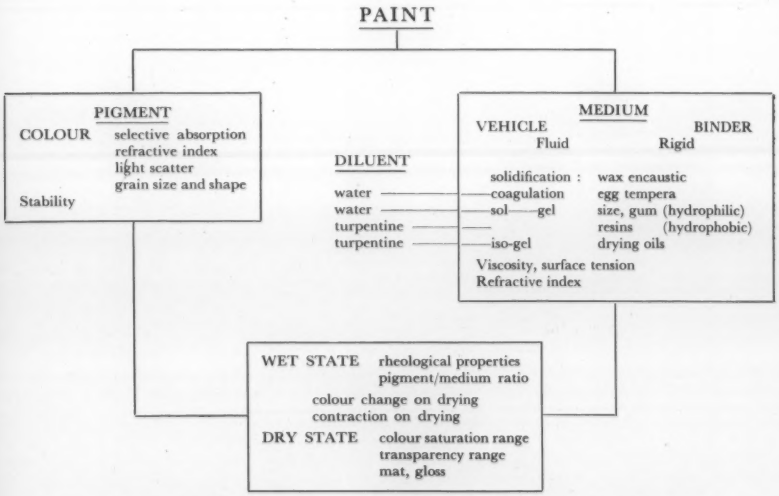

Fig. 1. *The primary and secondary properties of pigments, media and paint with which the artist is concerned.*

Pigments. For a coloured material to be selected as an artists' pigment, it must be a solid (the ravages of bitumen, which is not, are well known) which is chemically stable and inert towards the environment—the medium, the atmosphere and its contaminants—to the highest degree. The stringency of these requirements has limited the number of substances which have found a place in the palette : before the products of chemical manufacture in the nineteenth century became available, hardly more than a score are mentioned. Only about a half of these are found by analysis to have been in common use, and included among them are some which were difficult to use owing to their low tinctorial power. Fig. 2 shows the chromaticity of forty-six artists' pigments, the modern products being distinguished from those in

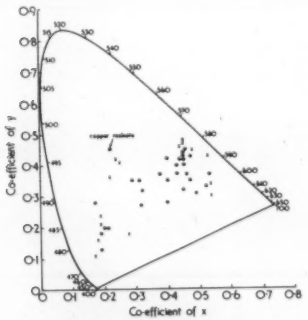

Fig. 2. *Chromaticity of artist's paint*
● Pigments available before 1750.
X Pigments which came into use some time after 1750.

use from earlier times. The extension of the chromatic range which the new pigments made available to the artist is evident ; some of them came in time for Turner,[1] and many more for the Impressionists and their successors. It also appears that the chromatic distribution is somewhat uneven, and if confined to the older pigments results in a patchy coverage, particularly in the yellows and greens. The position of the so-called copper resinate (made by dissolving a copper salt such as verdigris in Venice turpentine) would seem to make it a useful pigment, but it has unfortunately proved to be unstable, turning into a brown which is mostly copper oxide and decomposed resin. But the prevalence of this brown residue in Italian paintings up to the sixteenth century, shows how extensively this chromatically desirable pigment was used.

When considering the chromaticity available, it is important to recall the implications of subtractive mixture and the vagaries of the results.[2] This fact (together with the chemical risks) explains why analysis of paint shows that artists in general, and particularly before the seventeenth century—there are notable exceptions—have preferred not to sully their colours by mixing other than with white. The purity of pigments in a painting is often such that they can be identified by eye on their chromatic quality, and artists tend to speak in terms of the pigment names rather than of absolute colour.

Quite apart from the colour of the pigments are the attributes of transparency or opacity which they exhibit in varying degrees ; these interest the artist because subjectively, opacity gives an impression of proximity and tangibility ; transparency, of recession and shadow. These sensations are not unlike those implied by the terms object mode and illumination mode used in colour psychology. It is therefore of interest to consider the relevant physical factors. As is well known, the smaller the change of refractive index at an interface, the greater the intensity of light transmission. The importance of this effect is increased in the case of pigments owing (*a*) to the dependence of the refractive index on the absorption bands and (*b*) to the enormous number of interfaces present in a powdered material. The index varies rapidly through an absorption band from being low on the short wave side to high on the long. Therefore, red and orange compounds, with absorption toward the short wavelength end of the spectrum tend to have a high refractive index for the light which they do not absorb ; blues and greens on the other hand are likely to have a low index, since the band is in the long wave region. See, for example, the effective (i.e. for the light not absorbed) refractive indices shown in Table I :

TABLE I. EFFECTIVE REFRACTIVE INDICES

Vermillion, HgS	3·14, 2·82
Cadmium red, CdS(Se)	2·64 – 2·77
Iron oxide, Fe_2O_3	2·78, 3·01
Realgar, As_2S_2	2·46, 2·61, 2·59
Ultramarine, $3Na_2O \cdot 3Al_2O_3 \cdot 6SiO_2 \cdot 2Na_2S$	1·50
Azurite, $2CuCO_3 \cdot Cu(OH)_2$	1·73, 1·84, 1·76
Cobalt blue, $CoO \cdot Al_2O_3$	1·74
Prussian blue, $Fe_4[Fe(CN)_6]_3$	1·56
Smalt, (Co glass)	1·49 – 1·52
Malachite, $CuCO_3 \cdot Cu(OH)_2$	1·65, 1·90, 1·87
Viridian, $Cr_2O_3 \cdot 2H_2O$	1·82, 2·12
Emerald green, $Cu(CH_3 \cdot COO)_2 \cdot 3Cu(AsO_2)_2$	1·71, 1·78

The refractive index of the dried oil medium is about 1·5.

It is obviously desirable that the artist should be able to apply opaque and transparent paint throughout the range. This was achieved, as micro-sections of the paint films show, by adding white lead to blues and greens, and by using the transparent lake pigments at the red end. Lakes—dyes struck on aluminium hydroxide—appear to have been introduced in the fourteenth century, and obviously arose out of a desire to use the dyer's bright colours ; but there seems little doubt that they were appreciated for their transparency also. Certain vegetable dyes were used unlaked : indigo for example.

In the study of artists' pigments of the past another characteristic of importance is the grain size. Up to the nineteenth century paint was hand made, more often than not by the artist himself or his apprentice. With many pigments, particularly the powdered minerals, the

resulting product was far from being as fine or as homogeneously dispersed as the modern machine made product. The distinct texture can frequently be detected by the naked eye without microscopy, and the resulting optical characteristics are different. As the grain size decreases (up to diameters of half a wavelength), the opacity and light scattering increases. It is not unusual to find grains of 5μ diameter, and some of 10μ are to be seen among azurite, malachite, and smalt paint films. These are pigments of only moderate tinctorial power which become somewhat desaturated if too finely ground. The fact that there is an optimum grain size for each pigment was fully understood by medieval craftsmen, for Cennino Cennini[3] instructs in the case of malachite : " for the sake of the colour work it up very very little with a light touch ; for if you were to grind it too much, it would come out a dingy and ashy colour."

Media and Diluents. While the chemistry of paint media is complex, the physical essentials can be stated in fairly simple terms. The basic function of the medium is first to act, while fluid, as vehicle for conveying pigment according to the wishes of the artist, and second to become rigid through some chemical or physical change, thus firmly binding in place what has been painted. These are the two functional requirements which guided the early inventors of paint—the first in prehistoric times—in their empirical trials of whatever likely natural material came to hand. Artists appear to have employed, at one time or other, all the possibilities that might emerge from a theoretical approach to the problem. Thus, the liquid which solidifies through cooling is exemplified by the wax encaustic technique, wax being one of the few naturally available substances of convenient melting point. Theory would also suggest the colloidal materials : the gels, for example, are not over-readily unbound once the liquid component has evaporated, and they are, moreover, adhesive. Gels are in fact represented by gum, size, egg-white and the natural resins. Historically, the hydrophillic gels came first because a suitable organic diluent for oil and resin, was not available. Since the drying of gels results in contraction they are only satisfactory as thin films on absorbent surfaces as is the case with the water-colour technique.

Egg yolk and the drying oils, the two media of the greatest achievement in Western art, are also colloidal materials, but with quite unique properties to account for their pre-eminence.

The yolk, being an emulsion, can be handled with water as the diluent, and the paint made by simply adding yolk to pigments already ground in water. It dries quickly, and layer after layer can be applied without delay, thus enabling the painter to modulate the tones applied quite readily. Though the drying means a loss of volume—pure yolk alone contains 51 per cent water—the film is free from the contraction tensions which occur with gels. Furthermore, a short ageing period brings about changes in the protein structure which render the film insoluble in water and organic solvents, and remarkably resistant to chemical attack and long term ageing effects. Rheologically, the emulsion confers certain tactile qualities to the wet paint which the artist senses with his brush : it has body without being viscous.

The quality which distinguishes oil from the other media is that it does not dry by evaporation but by the formation of an iso-gel. The steric hindrance offered by the unique shape of the triglycerine molecules brings about setting with a quite low degree of polymerization. The process being slow in unmodified linseed oil, still slower in walnut and poppy oil, meant that little other than decorative work was feasible in the early history of the technique. Work calling for the application of successive layers and many brush strokes containing differing pigments would have required intermittent periods of tedious waiting for a certain degree of drying : records speak of exposure to sunlight for the purpose. Two developments however helped to overcome the difficulty and led to the general adoption of the oil technique ; it is regrettable that no precise dates can be given to these but both precede the sixteenth century. The first was the introduction of drying catalysts by heating the oil with calcined bones, copperas, or red lead. The second was the introduction of distillation products such as turpentine and spike oil as diluents. So important was this event that the remarkable technical advance evident in the paintings of van Eyck is not unreasonably attributed to it. To the artist of to-day using ready prepared paint, turpentine is simply a thinner but when artists prepared their own materials it also had the important role of making it easier to produce paint with a proper pigment—medium ratio. In hand grinding without a diluent, the tendency is to introduce too much medium because of the stiff consistency which obtains during the intermediate state of dispersion. Paint with excess oil imposes limitations on the artist : it may not be thickly applied on a vertical surface because it will flow ; it is likely to wrinkle when the upper layer dries because of sorption of the still liquid component by the gel at the surface ; and it lacks the stability to receive further layers of different paint. These restrictions do not apply to properly tempered paint, i.e. one in which all the grains are wetted and the interstices just filled with oil. Such paste-like paint may be too stiff for some requirements but the diluent gives the artist complete control over the consistency. By the seventeenth century the potentialities of this variable as means of expression were being fully exploited ; the rheological properties are an important element in painting technique so that everything appears from a thin wash to thick impasto, in such varied modes of application as brushing, smearing with the fingers or the palette knife, spattering and " controlled " accidental flow under gravity. The drying process in oil ensures that the surface topography is preserved with every expressive touch the artist makes. Such is not the case in a paint which dries by evaporation because of the contraction. Here then is one reason for the pre-eminence of oil as the artists' medium.

Oil is also more versatile optically because the refractive index is higher and closer to the pigment values than in the case of the aqueous media. This gives a greater range in colour saturation and transparency. It was for these qualities that oil first came to be prized as an artist's medium, so much so that it was used in the form of richly coloured transparent films over aqueous paint, and over tin and gold, before the technical

advances mentioned made its general use possible. Conversely, the Flemish oil painters would sometimes use gum or size as a medium for ultramarine, azurite and smalt when they wished to avoid the results of having pigments very close to oil in refractive index.

The refractive index of the dry oil increases with age according to A. P. Laurie. This he assumed accounts for the increased transparency which with the passage of time permits subjacent layers to be seen. Whatever the cause, the change permits previous states of the composition to be seen. They are termed *pentimenti* and are significant because they are more likely to be found in originals than copies.

With the above outline of paint technology as it is relevant to art in mind, it becomes possible to explore the technical characteristics of the paintings themselves. Much can of course be inferred from the straightforward visual examination but the range of knowledge is greatly extended by using various laboratory methods of exploration. These methods must essentially be either non-destructive or restricted to micro-samples. Analytically, it is possible to identify most of the pigments by micro-chemical methods[4] and the media by chromatography.[5] X-ray diffraction is useful but the size of sample required for the usual powder camera is larger than that for micro-chemical methods ; a flake of paint may sometimes be detached, inserted in the camera, and subsequently refixed in position on the painting. Certain pigments can be identified *in situ* by means of a back reflection camera.

Low-power stereo-microscopy of the paint surface is of the highest diagnostic importance : repainting is immediately apparent, as well as the commonest distinguishing feature of forgeries—falsified ageing cracks. With experience, the observer can discover much about the painting technique, about the condition, etc., in this way. The distinction between hand ground and modern machine ground paint can be made.

Fluorescence under ultra-violet radiation is useful in showing the distribution and extent of the restoration. This operates in two ways : the one depends on the fact that the visual colour match in the repair does not ensure a fluorescence match, and the other on the fact that the repaint is usually on top of a preliminary layer of varnish and under the final finishing coat ; the interposed repaint layer diminishes the brightness of the fluorescence of the varnish.

Microscopy, by reflected light, of paint cross-sections[6] mounted in a cold-setting polyester and polished, reveals details of the laminar structure of paintings and has ended much speculation about the working methods of the various schools of painting. Among the features to be seen are the succession of layers, the heterogeneity of the pigment mixtures, the grain size (Fig. 3). Also, it is possible to carry out some of the micro-chemical tests *in situ*. Observation is restricted to the moderate magnifications given by a 16mm or sometimes an 8mm objective, of low numerical apperture for choice. These have a depth of field (of the order of 10μ in a typical 16mm objective) comparable with the penetration of the light into the specimen; the high magnifications attainable

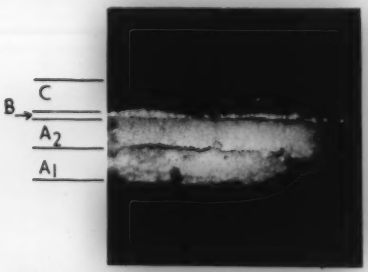

Fig. 3. *Cross-section of a fragment from a painting, typical of the technique used for blue robes of the Madonna in the fifteenth and sixteenth centuries.*

The layers are :

A_1, A_2 : chalk in animal glue. 0·1mm.
B : white lead with a few grains of azurite. 10 microns.
C : azurite with a little white lead. 0·1mm.
Grain size of azurite : 5 to 10 microns.

Fig. 4. *Infra-red photograph.* (Details from Brueghel: Massacre of the Innocents.—Royal Collection)

The photograph shows (1) the outline drawing (not strictly adhered to) on the ground under the paint, (2) overpainting applied in later years to transform the subject from an atrocity to " Sacking a Village." The figure of a child shows through the overpaint.

" Reproduced by gracious permission of Her Majesty The Queen."

with opaque specimens, e.g. metallographic ones, are thus ruled out. Again, because of the problem of light penetration, better results are obtained when the light is incident at as great an angle as possible to the normal. Such illumination is provided by suitably adjusted Beck-Chapman objectives. For greater magnifications, thin sections prepared in the manner of geological specimens may be viewed by transmitted light, but the image is less characteristic of paint than one due to reflectance.

Infra-red photography is used (Fig. 4) to explore sub-surface layers, and with greater effectiveness when a masking technique is used.[8] In this process the print is made from the infra-red negative plus a diapositive panchromatic mask of density and contrast suitable to suppress the surface and near surface reflections which are to some extent present in the infra-red image.

Next to surface microscopy, radiography is probably the most widely used means of examining paintings. The radiographs (Figs. 5, 6, 7, 8) yield information on the structure, the condition, the artist's technique, and the earlier stages of development which occurred during the creation of the masterpiece, to mention but a few aspects. Electron Emission radiography[7] offers intriguing possibilities but has not yet developed to be a routine procedure. Two features of the X-radiography of paintings distinguish it from the general run of industrial and medical work. The first is that the object is practically flat and relatively thin ; there is therefore no problem of scatter from parts of the object remote from the film and the image has almost the sharpness of a contact print. The second is the considerable variety of X-ray absorptions encountered : the paint thickness ranges from the maximum to zero owing to brushwork, etc. ; the pigment/medium ratio is a variable affecting the density ; and the pigments have mass absorption co-efficients derived from elements ranging from lead downwards. For the purpose of comparison, some indication of what is involved may be gleaned from a theoretical calculation of half value layers for some oil paint films. The mass absorption co-efficient is :

$$\frac{1}{1+A}\left\{\left(\frac{\mu}{\rho}\right)_p + A\left(\frac{\mu}{\rho}\right)_o\right\}$$

and the density :

$$\left(1+A\right)\frac{\rho_o \rho_p}{\rho_o + A\rho_p}$$

where the suffixes o and p refer to oil and pigment respectively, and A is the experimentally determined (and somewhat variable) ratio by weight of oil to pigment. Hence the half-value layer is given by :

$$0{\cdot}693 = \left\{\left(\frac{\mu}{\rho}\right)_p + A\left(\frac{\mu}{\rho}\right)_o\right\}\frac{\rho_o + A\rho}{\rho_o + A\rho_p} \cdot t_{0{\cdot}5}$$

The evaluations are set out in Table 2 for white lead, vermilion, gold, ochre, and aluminium hydroxide, the base in the organic lake pigments.

Ignoring those modern paintings with paint several millimetres thick, which in any case rarely occur as subjects for radiography, and confining attention to " old masters," the thicknesses likely to be encountered (as found on cross-sectioning) lie between about 100 microns and zero. (The exceptions to this figure are few, e.g. strong highlights). The values of $t_{0{\cdot}5}$ in the Table therefore confirm practical experience that the radiation at 15 to 25kV is appropriate for the heavy metal pigments but not for ochre, and paint of like absorption. For these soft radiation below 10kV is indicated, but regard must be had for anomalies due to the K limits of Zn, Cu, Co, Fe and Cr, elements which occur in several pigments. In practice most of the radiography is carried out in the upper of the two ranges mentioned, a second exposure being made in the softer region when detail is required from less absorbent paint.

At first it would appear that there are altogether too many variables for radiography to yield much information about the paint layer. This however is not the case because it is the distribution—by thickness and content of other colours—of what is in most painting techniques a widely used pigment, namely white lead, which is chiefly recorded. Were it not for the identity of lightness in the painting with lightness in the radiograph the image would be hard to interpret : in fact, certain techniques, as will be shown below, do not rely on this systematic use of white lead paint and the corresponding radiographs are somewhat featureless

TABLE 2. HALF-VALUE LAYERS OF OIL PAINT AND GOLD

Pigment	A	ρ_p	λ in Å	$\left(\frac{\mu}{\rho}\right)_p + A\left(\frac{\mu}{\rho}\right)_o$	$\frac{\rho_o \rho_p}{\rho_o + A\rho_p}$	$t_{0{\cdot}5}$
White lead	1/6	6·8	0·709	112 + 0·11	3·16	19·4 microns
Vermilion	1/5	8·1	0·709	114·5 + 0·14	3·09	19·8 microns
Yellow Ochre ... ... (composition: Fe 14% Si 25% A 8·5% O 51% H 1%)	3/4	3·5	0·709	7·9 + 0·52	0·91	0·90 mms
,,	,,	,,	1·537	68·3 + (1·5)	,,	0·17 mms
Aluminium Hydroxide ...	1	2·45	1·537	7·9 + (2)	0·67	1·05 mms
Gold	—	19·25	0·709	122	—	2·9 microns

or show complex tonal relationships. The presence of vermilion and other X-ray opaque pigments is not confusing because they are not directly connected with lightness. Incidentally, gold occurs in painting in the form of leaf hardly thick enough to record (circa 0·1 micron).

In addition to showing the features of the paint, the radiographs provide information on the structure (canvas, panel, etc.), the condition, past restorations, etc.

TECHNIQUE

Techniques of painting vary greatly from period to period and among individual painters, but for the present purpose it is helpful to consider three basic categories based on optical characteristics : (1) painting on a light ground (white, cream), (2) painting on a dark ground (red to brown, and very occasionally black), and (3) what is called the direct method in which the ground plays little part in the creation of form. The distinction between the three is often only a matter of degree and since each has advantages and disadvantages many forms of compromise occur ; most paintings have localized areas in the direct method, and grounds are found in grey, pink and ochre colour. Broadly speaking, the light ground technique is that of the Italians up to the Renaissance, and of the Flemish and many of the Dutch ; the dark ground, of the sixteenth century Venetians and their followers ; the direct technique is that most commonly used since the eighteenth century, though it does occur before then. Though this classification is based on the optical function of the ground, the subsequent painting procedures and consequently, the type of radiograph which they yield, each have their distinguishing characteristics.

Light grounds. In the most typical form of this method the artist begins with a panel which has been coated with chalk or gypsum in size—the medium most suitable for these low refractive index pigments. When brushed, size paint is apt to foam with a result often visible on a radiograph : surface craters filled by paint of subsequent layers, and minute holes. (Grounds in oil or emulsified oil do not show this result.) Next, the necessary outlines are indicated by drawing or by incising the ground. Infra-red photographs show the drawn line, often with remarkable clarity. Photographs of this kind may provide the art historian with evidence of the artist's first essay in a problem of composition. The drawn line has no appreciable X-ray absorption but the incised one is frequently seen on the radiograph as a sharp line which may be light or dark according to the absorptions of the superimposed paint layer which tends to fill the incision (Fig. 5). Radiography has shown that it was the practice to incise rather than draw with pen or brush lines which could be ruled (e.g. architectural ones), boundaries which had to be respected in subsequent work, particularly in the application of gold and tin leaf; and guiding lines for the complex folds in drapery which was to be thickly painted. This example of a craft procedure is one of many that were universal throughout Europe until the sixteenth century.

From this drawing stage the artist went on to define the forms achromatically by hatched lines or by a graded wash. Finally the colour was applied. In the simplest cases this is of semi-transparent thickness so that the previous layer effectively provides the form. The thickness applied depended on the intensity of colour required and on the pigment characteristics ; hence a characteristic of the surface topography is the presence of steps in the thickness at the boundary between two colour fields.

In Italian painting of the fifteenth and previous centuries which has survived, religious subjects predominate numerically. These subjects call mainly for figures clothed in folded drapery, the remaining parts of the picture surface being burnished gold leaf, or landscape and architecture treated as backgrounds not requiring to be highly coloured. In such works it is notable that the colourful drapery is modelled not by using black or other dark pigment for the recesses of the folds as the natural appearance might require ; instead the forms are rendered with a single pigment, or at most a binary mixture, and the modulation is largely effected by desaturation and increased lightness.[9] This is achieved by the addition of white paint or by thinner application over the light ground (Fig. 6). The fact

Fig. 5. *Radiograph (detail) of Verrocchio : Madonna and Child.* (Sheffield Art Galleries.)

The painting has been transferred from a panel to canvas owing to the decay of the wood which had caused the many losses of paint which appear as dark areas.

The image is remarkable for the precision of the preliminary drawing of the architecture. The lines are incised in the gesso with a sharp stylus, and show white because of the presence of lead in the first layer on top of the gesso.

The radiographic evidence of the architectural drawing, executed with such concentration on perspective, suggests the participation of Leonardo da Vinci who worked in the studio of Verrocchio as a young man.

that the pigments available to painters of this period differ in saturation and lightness, and hence in the range of tones available for modelling in this manner is evident in the paintings, as also are the devices adopted to overcome the resulting difficulty. For example, with vermilion, the range is found to be extended by superimposing a transparent organic lake of nearly similar hue over the " darkest " parts in order to increase the

Fig. 6. *Painting on a light ground* (Flemish, mid-15th century)

The support is radial cut oak, carved so that the frame is an integral part. Some worm holes have been filled with opaque material. The features are thinly painted on the white ground and show little X-ray contrast. The background appears white, being painted with white lead and blue azurite. Corrections to the profile are clearly shown.

saturation. In some egg-tempera paintings these so-called glazes are sometimes found to be in the more refractive oil medium which enhances the effect. Another convention, due to the lack of a deep yellow was the use of blue or purple for the shadows of yellow garments ; here contrast effects helped to offset the difficiency. In the case of flesh painting as distinct from drapery a greater degree of naturalism is demanded, but again the method was in keeping in that achromatic shade was avoided in many schools by using the complementary to pink flesh colour, the pale green terre-vert, as can be seen in Florentine or Sienese painting. In addition to paint, the metallic reflection of gold and tin leaf was used to add richness. Gold leaf was applied over red clay (bole) in an aqueous medium so that it could be burnished ; other clays would function but the choice of red to absorb the blue-green light transmitted by the leaf and hence increase the golden colour shows the extent of the craftsman's empirical knowledge. Throughout the technique there is evidence of the desire to prepare and to use materials in the way that best displays their intrinsic qualities.

All the procedures for this type of painting from the preparation of pigments to the final execution are lucidly described in the delightful *Il Libro dell'Arte* written by Cennino Cennini about 1390.

The early Flemish technique follows similar chromatic principles but with those arbitrary conventions for modelling described above less in evidence. The difference is due in part to the fact that the oil medium used provided a greater range in transparency and saturation, within which the painter could operate. The transparency ensured that the achromatic undermodelling showed with greater effect.

The light ground technique just discussed gives rise to radiographs which show a patchwork corresponding to the sharply defined fields of colour, each with a characteristic absorption coefficient and mean thickness. The Italian primitives, particularly, rely more on the gesso ground (which has a low X-ray absorption) than in additions of white lead for lightness : the resulting radiographs usually show little contrast.

With the Renaissance, the technique was modified to give greater weight to light values. The colouristic principles were partly retained but greater naturalism was achieved by modulating colour in the direction of dark as well as light : more of the colour triangle of a given hue was utilized than the region between the pure pigment colour and white. The scientific observation of nature, particularly by Leonardo da Vinci, led artists to think in terms of this *chiaroscuro*, and of aerial perspective (the effect of light scatter by the atmosphere) ; the contours of rounded objects were treated so as to take account of the tangential orientation (previously figures and objects tend to have a " cut out " look). Leonardo did in fact place more emphasis on these effects than on achieving brilliant colour. It is perhaps significant that analytical cubism is concerned with the effect of orientation on the luminance of a plane, and on contrast effects, at the expense of colour.

Dark Grounds. In this the canvas was coated with a dark red or brown acqueous paint, and that gave the shadow. By applying colour thin enough to be translucent, half tones were obtained, and full tones by complete coverage ; forms were also created by wiping off paint already applied, by smearing, etc. ; the latter act was effectively used for producing soft contours. The method permits rapid working—it was the method of the Venetians for producing their very large canvases. Subjectively, the absence of paint in the shadows, and the thick loading of the lightest parts tends towards greater realism because the eye is less conscious of the plane of the picture.

Many artists practising the technique in the sixteenth and seventeenth century retained one feature of the earlier method in that complex pigment mixtures were little used in order to avoid subtractive mixture, but subtle modulations were obtained by superimposing transparent glazes. It is also evident in the pictures that

successive contrast phenomena come into play as the eye follows directions suggested by the composition.

The technique suffers one serious disadvantage, however, owing to the effect of the slow increase in the transparency of oil paint with time ; as a result, the half tones darken but the thick lights remain unchanged : in photographic terms, the effect is one of excessive contrast.

Paintings so dependent for form on paint thickness are ideal subjects for radiography (Fig. 7). The results often reveal gradations in tone which have vanished optically owing to the ageing effect already mentioned.

The Direct Method. The essence of this technique is that the artist mixes paint freely to obtain the desired colour and value, and applies it more or less opaquely. Most paintings are likely to have some passages done this way, but when practised with ready prepared paints from tubes—these are more opaque than much of the

Fig. 7. *Painting on a dark ground.*
(Detail from Velasquez: A Woman Cooking Eggs.—The National Gallery of Scotland)
The canvas grain is hardly seen because the priming is a dark red earth pigment. Where a priming contains white lead the canvas weave is strongly marked on the radiograph. The paint thickness is directly related to light and shade in this technique and the X-ray image corresponds closely to the visual. Individual brush strokes, which follow the forms, become more evident in the radiograph. "By permission of the Trustees."

Fig. 8. *Direct technique*

The relation between the X-ray and visual images is complex because of the use made of colour juxtaposition in this detail from a pointillist painting (Seurat : La Poudreuse.—Courtauld Collection). Neither the paint thickness nor the white lead content directly define the form of the head.

hand ground variety—the utmost degree of freedom prevails, and the vast diversity of nineteenth and twentieth century painting would hardly have been possible in the more rigid earlier procedures. Some of this modern painting is of scientific interest because of the use made of visual perception phenomena like simultaneous contrast, colour recession, etc.

Where forms are created by lightening or darkening the colour, the radiographic image is consistent with the painted image, but where they depend on various chromatic effects instead of light and shade, as in post-impressionism and schools derived therefrom, the relation between the two images is more complex, and no generalizations are possible. An extreme case is the radiograph of a Pointillist painting (Fig. 8).

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Notes and News

Extraordinary General Meeting

NOTICE IS HEREBY GIVEN that an Extraordinary General Meeting of The Institute of Physics will be held at 4 p.m. on Tuesday the 5th day of July, 1960, at the Institute's House, 47 Belgrave Square, London, S.W.1. (This business meeting is open only to Honorary Fellows, Fellows and Associates.)

The business to be conducted is

(*a*) the consideration of the Board's report and the accounts and balance sheets for 1959, a copy whereof was printed in the April, 1960, issue of the *Bulletin* and

(*b*) to consider and if thought fit to pass the following resolutions which will be proposed as Special Resolutions :

Resolution 1. THAT the Company incorporated under the Companies Act, 1948, on the 17th day of May 1960 and known as The Institute of Physics and The Physical Society, having objects similar to the objects of the Institute and prohibiting the distribution of its income and property amongst its members to an extent at least as great as imposed on the Institute by Clause 4 of its Memorandum of Association, is an institution to which the Institute may on a winding up or dissolution transfer its assets.

Resolution 2. THAT upon the liquidation of the Institute proposed by the next following resolution the remaining assets of the Institute after satisfaction of all debts and liabilities be paid or distributed to The Institute of Physics and The Physical Society.

Resolution 3. THAT the Institute be wound up voluntarily and that ERNEST WILLIAM COLEMAN of Messrs. Knox, Cropper, Gedge & Co. of Spencer House, South Place, E.C.2, and HERBERT RAPHAEL LANG, Secretary of The Institute of Physics of 47 Belgrave Square, London, S.W.1, be appointed liquidators for the purposes of such winding up.

Members will note that this meeting will have dealt with the business on the agenda for the Annual General Meeting originally convened by Notice in the April *Bulletin* for 5 p.m. on July 5; that meeting will not therefore be held.

F. A. VICK,
Honorary Secretary.

June 10, 1960.
47 Belgrave Square,
LONDON, S.W.1.

A Physics Anthology

A leaflet giving details of *A Physics Anthology* is enclosed with this issue of the *Bulletin*. The book is to be published this month. Members who wish to obtain copies at the special price of 27s. 6d. post free should send their orders, with remittances, to the Institute. Orders at the full retail price of 35s. must be placed through booksellers.

Mechanical Design of Laboratory Apparatus

The latest volume in the "Student Monograph" series is *Mechanical Design of Laboratory Apparatus* by Dr. H. J. J. Braddick. The retail price is 6s. but members may obtain copies for their personal use at the special price of 4s. 6d. post free. Orders at the reduced price should be sent to the Institute with remittances.

International Conference on Physics Education

As has been previously announced, the Institute has provided the secretariat of the International Conference on Physics Education. The conference is sponsored jointly by the International Union of Pure and Applied Physics, the Organization for European Economic Co-operation and Unesco, with support from the American National Science Foundation. It is to be held in Paris at the end of July. Attendance at the conference has been strictly limited so as to ensure useful discussion and, although almost 30 countries will be represented, the total attendance will be only 100 people. The British representatives have been chosen so as to cover the various fields of educational interest; they are Dr. H. F. Boulind, Mr. N. Clarke (who is also Secretary of the whole Conference), Professor G. K. T. Conn, Mr. H. W. French, Professor M. R. Gavin, Dr. J. M. A. Lenihan, Mr. G. R. Noakes (who is organizing the British contribution to an exhibition of books and apparatus) and Dr. J. Topping.

It is hoped to issue the Conference proceedings before the end of the year at a price low enough to ensure their wide distribution.

The Structure of Metals and Intermetallic Compounds

Professor Linus Pauling, of the California Institute of Technology, has accepted an invitation from the Metal Physics Committee of the Institute of Metals to give a lecture during his forthcoming visit to Britain. His lecture on "The Structure of Metals and Intermetallic Compounds" will be delivered at the Royal Institution, Albemarle Street, London, W.1, at 6.30 p.m. on Monday, July 25, 1960. Visitors will be welcome; tickets are not required.

Rheology of Polymers

The British Society of Rheology will hold a meeting on the rheology of polymers at Swansea on September 8, 9 and 10, 1960. Further details may be obtained from Dr. M. F. Culpin, 8 The Broadway, Pontypool, Monmouthshire, S. Wales.

Sixth Annual Conference on Magnetism and Magnetic Materials

The Sixth Annual Conference on Magnetism and Magnetic Materials will be held in New York City, November 14-17, at the New Yorker Hotel. This conference is sponsored jointly by the American Institute of Electrical Engineers and the American Institute of Physics, in co-operation with the Office of Naval Research, the Institute of Radio Engineers and the Metallurgical Society of the A.I.M.E.

Authors should submit titles and abstracts of proposed papers by August 26 to A. M. Clogston or R. C. Fletcher, Program Chairmen, Bell Telephone Laboratories, Murray Hill, New Jersey. Further conference details can be obtained from the Local Chairman, L. R. Bickford, Jr., I.B.M. Research Center, Yorktown Heights, New York.

Forthcoming Meetings

Date	*Place*	*Speaker*	*Title*	*Time*	*Branch or Group*
June 25			Summer meeting: visit to the Clarendon Laboratory.		London and Home Counties
June 16 and 17	**Seascale** Windscale Club		Summer meeting. Registration is necessary.		Applied Spectroscopy
July 1			Summer meeting: visit to Royal Radar Establishment, Malvern.		South-Western
	Registration is necessary. Full details may be obtained from the Secretary of the Branch.				
July 5	**London** The Institute's House		Extraordinary General Meeting	4.00 p.m.	
		(See notice on previous page.)			
July 6			Summer meeting: visit to Calder Hall.		Manchester and District
July 13	**Derby**		Summer meeting and visit to Rolls-Royce Altitude Test Plant		Yorkshire
	The number for this visit is limited.				

Reviews of Books

ENCYCLOPEDIC DICTIONARY OF ELECTRONICS AND NUCLEAR ENGINEERING

By Robert I. Sarbacher

London : Sir Isaac Pitman & Sons Ltd. Pp. x + 1417. Price £8 8s.

It is always debatable just how far the immense amount of work necessary to prepare a work of this kind, and the correspondingly high cost, are justified. A scientific encyclopedia consisting mainly of long articles (of which there have been one or two outstanding examples in the past) does serve a useful purpose I think if it is limited to a fairly restricted field of science. The present work cannot be described in this way, although of its kind it is an admirable example. It is designed, so the preface states, for the scientist, technician or student working in the fields of electronics and nuclear engineering although a precise definition of either or both of these activities would be difficult to give.

It must be stated at once that the technical quality of the work is extremely high. The diagrams, of which there are many, are very clear and many are of great value in themselves. Perhaps it is when one examines fairly closely the kind of entries that are made in the encyclopaedia that one begins to have misgivings and it then becomes clear that in order to cover the two fields mentioned it is necessary to give many entries from other fields, for example optics. Many of the entries occupy no more than half a dozen lines of print and I feel that for experts these are of doubtful value. For example, to give an extreme case, an aperiodic function is described as a function that is not periodic. However on the other hand there are many aspects of electronics and nuclear engineering which are treated to the extent of a page or two in some detail and are potentially of considerable use. Examples of this kind are the entries on bridge measurements, and particularly on nuclear reactors, of which a comprehensive list enumerating the different types is given covering about ten or eleven pages. It might have been better if the fields treated had been restricted so that this kind of entry could have been more numerous because there is no doubt that lists of this kind are of great value. Transistors again occupy about ten pages and constitute in my opinion a useful contribution. It is also generally true in works of this kind that specialists, who admittedly would not normally use the book for their own field of work, tend to be dissatisfied with the entries relating to their own work ; for example there are six small entries on recombination, a matter of some importance in gaseous electronics, but the sum total of these gives a negligible amount of information. If many of the small items had been cut out and replaced by some detailed contributions on chosen subjects the work might have been more valuable and it is certainly difficult to imagine private individuals purchasing it for their own use in its present state, admirable though the work may be as a whole.

There are over fourteen hundred illustrations and over fourteen thousand entries comprising more than one million words so it will be seen that an immense amount of scholarship has gone into the preparation of this book.

J. D. CRAGGS.

PROGRESS IN NUCLEAR ENERGY — HEALTH PHYSICS

Edited by W. G. Marley and K. Z. Morgan

Oxford : Pergamon Press Ltd. Pp. x + 602. Price £5 5s.

The conference is an activity to which Professor C. Northcote Parkinson might usefully direct his quizzical scrutiny. The early gatherings of the Royal Society and the Victorian assemblies of the British Association served the cause of science very well, but recent developments have included many absurdities, culminating in the 1958 United Nations conference on the peaceful uses of atomic energy. Preceded by a virulent epidemic of *scribendi cacoethes*, this meeting brought together some 6,000 delegates, observers, spectators and reporters, ostensibly to receive and discuss more than 2,000 papers. Few participants admitted much enthusiasm for this part of the exercise, though many insisted that good work was done informally at the bar of the Beau Rivage or on the road to Chamonix.

The full proceedings have been handsomely interred in 33 volumes published by the United Nations. The present work forms part of an unofficial but authoritative abridgement. The original illustrations and bibliographies are reproduced but the discussions which followed the papers read at Geneva are not included. The 45 selected papers are arranged under six main headings, two dealing with the organization of radiation protection for people occupationally exposed, two with the measurement of radioactivity and two with environmental hazards from atomic energy. The first group includes an interesting survey of the work of the International Commission on Radiological Protection, a discussion of the methods used in evaluating maximum permissible levels for various hazards and a number of reports on operational experience in uranium mines, factories and atomic energy installations.

The next section is devoted mainly to instruments and techniques for the measurement of traces of radioactive material inside the body ; it includes the often-quoted paper by Mayneord and his colleagues on the alpha-ray activity of the human body. The remaining papers deal with the hazards of airborne radioactivity, the disposal of waste materials into the ground or the sea and the uptake of fission products from the soil. A long account of the measurements made after the Windscale accident in 1957 is particularly useful.

Written, naturally enough, in many different styles and degrees of sophistication, the book recalls the Scotsman's judgement of the sheep's head—" a deal o' rich confused feeding "—but it will prove serviceable both as a work of reference and as a conspectus of the duties undertaken by physicists responsible for the control of radiation hazards.

J. M. A. LENIHAN.

TEXTBOOK OF PHYSICS

Edited by R. Kronig

London : Pergamon Press. Pp. xiv × 961. Price 84s.

The Textbook of Physics, written after the second world war by a number of distinguished Dutch physicists under the editorship of R. Kronig, became known in translation to English readers in 1954 and was an immediate success. Since then there have been four revisions of the Dutch original. The second English edition has now appeared and will be recommended for the qualities possessed by the first edition and for new features of its own. Like the first it covers the whole field of physics starting with mechanics, proceeding to electrodynamics and optics, thence to atomic and nuclear physics. Finally there is a chapter on instruments and one on medical physics. The last two chapters as well as the section on nuclear physics, have been extended and modernized. They do not seem completely up-to-date even now, but that perhaps is because developments in these fields grow overnight. The general impression produced by the book is good, and it is excellent to put into the hands of honours students to give them a broad survey of physics. Problems have been added at the end of each chapter, and these will be useful to test the readers' understanding of the principles involved.

The chapter on optics is variable in standard. It is good to have a discussion on coherence, but the sections on polarized light are too brief. There is, for instance, only a partial explanation of the need for a half shadow field in polarimetry. The Weber-Fechner law is not mentioned, nor is it referred to in connexion with photometry, where it is the governing principle, although it is stated in the chapter on medical physics, where there is a back reference to the section on photometry. (Incidentally the index also fails to include any reference to the law.) However, a couple of pages are devoted to the optics of the photographic emulsion, a subject on which the average student has a distressing ignorance.

There are some omissions, a somewhat unexpected example being the lack of any discussion of the viscosity of liquids. However, to give instances where the book falls short of satisfying the personal tastes of the reviewer is really to imply how good a book it is, for otherwise omissions would cause less surprise. It is a pity that so good a book should not have had better diagrams, with a crisper appearance; most of them suffer by being too small. The translation is good, and the reviewer has noted only a single oddity. In the description of the liberation of bubbles in a bubble-chamber the text on page 486 runs " a high energy particle traversing the chamber then declenches ebullition on its way " the meaning of which is no doubt clear, but the etymology may puzzle anyone who does not remember that *déclencher* is to unlatch.

A. M. Taylor.

SIMILARITY AND DIMENSIONAL METHODS IN MECHANICS

By L. I. Sedov

London: Cleaver-Hume Press Ltd. Pp. xvi + 363. Price 105s.

This is really two separate books within the same pair of covers. First of all Chapters 1-3, some 145 pages, are devoted to the discussion of similarity and dimensional methods and their application to a variety of problems in mechanics and fluid mechanics. Then, as an almost separate entity, the two remaining chapters, some 200 pages, are devoted to the one-dimensional unsteady motion of inviscid gases, the prime applications being to explosive phenomena and astrophysics.

To deal first with the first three chapters, the author steers, as he says in the preface, a middle course between the extreme opposing views that similarity and dimensional theory is, on the one hand, all powerful or, on the other, to be expected to give only trivial results. In fact I don't think he diverges far from the view expressed by Birkhoff in his book *Hydrodynamics* that " one must resort to ' inspectional analysis ' . . . testing for invariants . . . every fundamental mathematical equation on which a theory is based." This is well illustrated by Sedov's discussion of Bridgman's elucidation of the Rayleigh-Riabouchinsky exchanges on dimensional theory in heat transfer in fluid mechanics and the paradox that the more one knows the less precise are the results of dimensional theory. It isn't really until one writes down the equations of motion, continuity and energy transfer together with their boundary conditions that one can decide in any given problem such as Rayleigh's which are the *significant* parameters and which may be neglected. Dimensional analysis in such a framework of inspectional analysis then comes into its own.

Turning now to the second part of the book I must in fairness add to my opening comment that the approach to one-dimensional gas flow is dimensional in the sense of my last paragraph, though much of it could in fact have been written without specific reference to dimensional analysis at all. This is in my view much the more important part of the book. It and the succeeding chapter on astrophysics contain much that is new and valuable about self-similar solutions in the theory of spherical explosions—a large part of it the recent work of the author and his group at Moscow University. It is however interesting in this connection to note that the only plate in the book consists of a reproduction, from Sir Geoffrey Taylor's 1950 paper, of photographs of the fire-ball of an atomic explosion in New Mexico.

It is pleasant to record that the book is well-documented with references and for my part I can thoroughly recommend the second part to all serious students of the branches of fluid mechanics which deal with explosive phenomena and astrophysics. It is perhaps a pity that the two parts were not got up as separate books, for at 5 guineas the price is expensive.

L. Howarth.

SOVIET SPACE SCIENCE

By Ari Shternfeld

London : Hutchinson & Co. (Publishers) Ltd. Pp. xxii + 361. Price 30s.

Any book on Space Science is liable to date rapidly in these days. This is especially true if it is primarily concerned with Soviet work, for the cloak of secrecy which enfolds their plans ensures that only that which

has already been accomplished is mentioned in any detail. Moreover the same cloak results in Soviet books giving disproportionate attention to the plans and details published in the West.

Soviet Space Science is a translation by the United States Air Force Technical Documents Liaison Office of the second edition of a book by Shternfeld, first published in Moscow in 1957. The second edition left the author's hands a few days after the launching of the first two Sputniks. The present translation has a foreword by Willy Ley and an inconsequential epilogue by the same writer, referring to more recent events.

The book is intended for popular reading and is remarkable for unusual restraint and absence of propaganda. It undoubtedly gives a good idea of the way one section of the Soviet public is thinking, in much the same way as do the publications of the interplanetary societies of the West. Whether this is a wise way for men and nations to think is another matter.

Soviet Space Science should be immensely popular with schoolboys. It gives a large number of useless tables of data on all manner of things connected with the motions of artefacts in Space.

R. L. F. Boyd.

DEFORMATION STRAIN AND FLOW — AN ELEMENTARY INTRODUCTION TO RHEOLOGY

By Markus Reiner

London : H. K. Lewis & Co. Ltd. Pp. xiv + 347. Price 63s.

In the present book Professor Reiner has given us an eminently readable account of the theoretical principles and methods of measurement basic in rheology. Elasticity, viscosity, creep, visco-elasticity, as well as the more complex properties of materials are discussed, and the theory of some rheological instruments, such as rotation viscometers, is developed.

The book is not, and was not intended to be, exhaustive. Mathematics are kept to the essential minimum, the methods are elementary, and rigour for its own sake is not pursued. Here and there one discovers the unexpected : fresh paint is explained to be a solid, a cylinder subject to torsion is shown in some cases to lengthen rather than shorten, and with a little know-how a rheologist can pour tea out of a pot in a C-shaped stream.

This is a friendly book : it should find a particular welcome with teachers, students, and all those engaged in the study or development of materials, new or old.

P. Feltham.

CRYSTAL GROWTH : DISCUSSION OF THE FARADAY SOCIETY No. 5, 1949

London : Butterworth's Scientific Publications. Pp.366. Price 60s.

It is now more than ten years since the Faraday Society held its discussion on Crystal Growth at Bristol. However, it would appear from this second printing of the papers and discussions of that meeting that the original material is still of considerable interest.

It was during this meeting that the significant change in attitude to the initial stages of crystal growth took place, chiefly through the major contribution of Frank in his paper and in discussion sections. It is stimulating reading to follow the details of the introduction of dislocation theory and reactions to it and to recognize problems raised which have subsequently been solved by its application. In this text most of the important methods for crystal growing are mentioned, those for crystallization from the vapour phase only briefly. However, the reader will note that methods used extensively in research and industry for germanium, silicon and intermetallic semiconductors were developed after 1949, e.g. the zone growing and purification techniques of Pfann published in 1952. The discussions on hydrothermal synthesis of quartz, etc., marked the beginning of an industrial method to replace rapidly dwindling natural resources. It is certain that as a landmark in the history of crystal growth this volume should be in better supply, a matter which the new printing has remedied. It would have been useful if, in doing this, the publishers had taken the further step of including a detailed subject index.

G. F. J. Garlick.

TOWARDS A UNIFIED COSMOLOGY

By Reginald O. Kapp

London : Hutchinson and Co. Ltd. Pp. 303. Price 35s.

This book is a gallant but inevitably unsatisfying attempt at a major project which the wider minds in physics cannot indefinitely postpone. The aim is to reduce to a minimum the principles and assumptions demanded by a scientific cosmology. Such a project has, of course, been approached piecemeal by most investigators, physical and astronomical, with varied success but little generality : Professor Kapp achieves the generality but pays heavily for it. He has to discuss within a single volume astronomical mechanisms (strangely the work of Weizsäcker on pre-galactic clouds does not seem to be considered), also principles of conservation and the foundation of physics, as well as epistemological principles of causation and of the meaning of the word "understand." It may be debated whether these can all be served by the same language. As a commentary on the topics which ought to be raised by any reading of relativistic cosmologies, the book is a valuable stimulant; but this virtue imposes on it the stigma of being very difficult to read or judge.

Martin Johnson.

PROBLÈMES ACTUELS EN THÉORIE DE LA RELATIVITÉ

Paris : Revue d'Optique Théorique et Instrumentale. Pp. 124. Price 12,00 NF.

Not only the Special Relativity of the Lorentz equations but General Relativity have long become conventional chapters of textbooks, and physicists have tended to accept the notions copied into those books from the 1920's and imply that all is well with the

" observational verifications." This small volume of papers collected in 1958 at Paris is a salutary reminder of what a number of vital and yet unsettled queries have to be answered before the physical situations envisaged in Relativity are finally acceptable. The papers are concerned mainly with facts obtainable in laboratory and observatory, and though not all by French writers they have all caught something of the French tradition of clear exposition. Topics range from optics to thermodynamics, and of course emphasize electrodynamics and the ambiguities in the measurement of Time. We might mention especially the paper by Stamatia Mavridès, and the theories of " red shift " alternative to the conventional " expansion of the universe " which has too easily in some quarters dressed itself in a mantle of " accepted fact." In view of recent Harwell and other experiments on gravitational red shift by gamma rays, it is important that the original Einstein solar red shift rediscussed by Finlay-Freundlich is here subjected to empirical critique. The Oxford solar observers with their cautious recent estimate of a solar limb effect 30% exceeding that of Einstein are not mentioned, but in reading these French papers must not be ignored.

MARTIN JOHNSON.

A SOURCE BOOK IN MATHEMATICS

By David Eugene Smith

London: Constable & Co., New York: Dover Publications Inc. Pp. 701. Price 28s.

The 96 selections collected here cover a period from the invention of printing to the close of the nineteenth century. Some consist only of a single key paragraph: others run to nearly 20 pages (in one case, more). Translations and annotations have been made by a variety of experts on the topics concerned, to provide illustrative material complementary to histories of mathematics.

Differences of notation are something of an obstacle with the algebraic and analytical papers until about the period of Euler. This is less so with the geometric material (starting with Desargues), or with arithmetic and number theory.

Reference to original sources is educative in two distinct ways. Something of the personality of famous mathematicians comes through on reading their actual words, and in many cases their original expositions have not been appreciably bettered by their successors. A notable example here is the Fermat-Pascal correspondence on fundamentals of probability theory.

With other papers the reader is similarly carried back in time to a well chosen set of points of significant discontinuity in the upward progress of mathematics—an exciting experience for any true mathematician.

T. H. O'BEIRNE.

FROM EUCLID TO EDDINGTON

By Sir Edmund Whittaker

New York : Dover Publications. Pp. 204. Price $1.35.

The sub-title of this book, " a study of conceptions of the external world," is appropriate, but the main title might suggest that it was a condensed history of physics from the time of Euclid to the present day. It is something much more important, for it is a description and discussion of the evolution of the concepts used in physics. One hopes that every physicist meets these in the course of his education, but perusing the book again strengthened one reader's prejudices that its content should form the basis of a course of lectures for undergraduates. The aim would be to enable them to subject the fundamental concepts in physics to a more searching scrutiny than is usually possible at the stage at which they are first introduced to these ideas.

The first section of the book deals with space, time and movement ; it must be hard reading for a beginner, but a helpful, connected account for others. This applies equally to the next three parts which are concerned in turn with the concepts of classical physics, of general relativity and of quantum mechanics. The final part is a sympathetic review of the work of Eddington linking general relativity and particle theory.

One always admires Whittaker's lucid writing and his erudition. It is good that this valuable work of his has again been made available in this cheap edition.

J. TOPPING.

DESIGN FOR A BRAIN—2ND EDITION

By W. Ross Ashby

London: Chapman & Hall Ltd. Pp. ix + 286. Price 42s.

This is manifestly an important book: it is, at the same time a production characteristic of 1960. Since the first edition of some eight years ago, much has happened, more especially the rise of cybernetics and the appearance of information theory as a vigorous mathematical discipline. The connection of these subjects with research into the physics of the nervous system (and all appertaining thereto) is obvious enough. What the author has done is to give this relationship a formally logical structure and to put " brain-mechanics " in their proper place. In thus acting, he implies complete faith in a system of a deductive nature, rather as geometry supports astronomy, or for that matter, many parts of physics. So far so good. It is a significant advance, but on one condition. That is that we do not forget the limitations set upon *all* axiomatic methods by Gödel's theorem. In the last resort, knowledge is likely to advance by understanding more than by prediction. This is not a criticism but a comment. Meanwhile, it is demonstrated with considerable force that a system can be both mechanistic and adaptive, with the additional factor that a machine's behaviour may be very adaptive indeed, in fact to any desired degree. It is claimed that the process can be carried far enough to explain the adaptiveness of man. The stability theorems needed for such state-determined systems are, of course, largely of a topological character, though they resemble in certain ways the equations set up for his " system-theory" by Bertalanffy. This is natural, since underlying both is some sort of " steering " concept, closely linked with cybernetics and feed-back mechanisms. As the writer remarks, much of the mathematical technique is founded upon the French collectivist work known as Bourbakis' *Eléments de Mathématiques*. Here we meet the modern counterpart of Boltzmann and Willard Gibbs, so far as

Design for a Brain is concerned. In brief, all isolated state-determined systems are selective, and tend to very rigid (i.e. exceptionally resistant) end-states. Closer examination reveals how highly co-ordinated the internal patterns can be, as if they were " determined "to suffer no re-orientation if they could possibly help it. The influence of environment upon the " learning " organisms seems particularly strong.

The author writes with clarity and the plan of his book, with its decimal notation for sections and illustrations is excellent. Perhaps he may not obtain universal agreement with his thesis, but he has provided yet another pointer to the truth of many people's conviction that the most interesting branch of physics in the future will be bio-physics, and the almost limitless vistas which they offer.

F. I. G. Rawlins.

GENERAL CRYSTALLOGRAPHY: A BRIEF COMPENDIUM

By W. F. de Jong

London: W. H. Freeman & Co. Ltd. Pp. ix + 281. Price 38s.

The author of this book claims that crystallography is now as important a branch of physics as, say, thermodynamics and that it therefore now needs its undergraduate textbooks. Whether one agrees with this claim or not, it is certain that, with the present developments in solid-state physics, one cannot brush the subject aside with brief references to unit cells (cubic, for simplicity) and Miller indices; physicists need a broader basis than this.

Nevertheless, the author does not claim that this compendium forms the right type of textbook, and I certainly agree with him. As the word " compendium " implies, the text is considerably compressed, and students using the book for private study may well suffer from mental indigestion. The following extract—admittedly an extreme one—provides an example of the style.

" A line through two lattice points is called a *lattice line;* the lattice points lying on a lattice line form a point row. Through each point of a lattice there is a lattice line parallel to a given lattice line; all these lattice lines are indistinguishable, identical; and the whole is called a spatial range."

The book will probably be more useful for the preparation of lectures; the author writes with obvious competence and covers an extremely wide range of subjects. There are four general sections—geometric, structural, chemical and physical crystallography, each illustrated by many beautifully drawn diagrams. To the physicist the most interesting section is the last, which deals extremely efficiently with most matters of current interest in crystal physics.

Although efficiency is the keynote of the book, I think that the author has made some errors of judgment. He introduces new names for old concepts where he thinks they are needed; admittedly " superlattice " is unsatisfactory, but it is so well established that " over structure " is hardly likely to replace it. He introduces new terms—at least they are new to me—such as conjugate range, diadochic atoms, ogdohedry, and sheaf (meaning a set) of axes. It would be a great pity if the student gained the impression that crystallography involved merely remembering a multitude of names. And finally, he does not use entirely standard symbols for symmetry elements. Admittedly they do not differ greatly from those in the International Tables, but why do they differ at all ?

To summarize then, I would say that this book could be a very valuable one to those who, already at home with the subject, require a work of reference. For the student, however, it is not recommended unless he is told clearly which parts of the book he should omit.

H. Lipson.

SPACE FLIGHT—VOLUME I—ENVIRONMENT AND CELESTIAL MECHANICS

By K. A. Ehricke

London: D. Van Nostrand Co. Ltd. Pp. xiii + 513. Price £5 9s.

A number of books in a series entitled *Principles of Guided Missile Design* have already appeared. The subject of Space Flight is to be treated in three volumes of which the book under review is the first. Subsequent volumes will be Dynamics and Space Operations. The first volume introduces the concept of space flight and the environment in which it will take place so far as we know, and then deals with astronomy and celestial mechanics from the point of view of the astronautical scientist. The series as a whole is being written for university students, scientists, engineers and technical officers of the Armed Services and the publishers hope that this particular volume will be valuable in day to day research and development work.

Part I comprises chapters on the history and utility of space flight and on the Solar System. Part II deals in three chapters with the central force field, orbits in space, and perturbations. Although the determination of the orbital elements of a body from observations of it is described as one of the most important problems of astronomy, it is dismissed in a few pages. The subject of perturbation receives a much more adequate treatment.

The book is very well produced with many graphs and illustrations. There are numerous references to published papers some of which are remarkably up-to-date. Problems are given at the end of each chapter on celestial mechanics. Although the author is fully aware that high-speed computers are essential in missile technology, attention in this book has been given to methods of hand calculation and short-cut methods. When a book contains so much information it is perhaps unfair to complain about the length and expense. However, it must be said that if a less discursive style had been adopted, the same amount of material could have been packed into far fewer pages with a corresponding increase in clarity and reduction in price.

The author is to be congratulated on the amount of material he has collected together and the publishers on the speed and efficiency with which they have published it.

J. Crank.

The Register

ELECTIONS TO MEMBERSHIP

THE FOLLOWING ELECTIONS WERE MADE BY THE BOARD ON MAY 3, 1960

An asterisk (*) indicates transfer from another grade

FELLOWS (15)

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Wood, Albert Roy, B.Sc., Assistant Physics Master, Leeds Modern School, Leeds.
Worsfield, David Leslie, B.Sc., Technical Officer, British Nylon Spinners Ltd., Pontypool, Mon.

Twenty-six Students and four Subscribers were also admitted.

Letter to the Editor

The Postgraduate Training of Physicists in British Universities

I have read with interest the report on *The Postgraduate Training of Physicists in British Universities* and particularly note that a Ph.D. is considered essentially as leading to a research career and also that only the work of physics departments has been considered.

In this University some physics graduates have gone on to undertake research projects in many other departments including this chemical engineering department, electrical engineering, metallurgy and mining. Most of them on attainment of their Ph.D. would still aspire to be physicists whatever their departmental label but they will not necessarily hope to follow a career in pure research. Nor would this be desirable for surely the Ph.D. training is not solely training in research but more advanced training of the mind in tackling problems. It is thus much broader and more important than pure research. This aspect has a special importance in view of the necessity for introducing more and more graduates capable of using scientific method and with scientific habits of mind into all branches of industrial management if we are to maintain our position as regards other countries.

Physics graduates working in applied science departments will be working in intimate contact with others of quite different background and they will already be well aware how artificial are the boundaries implied by departmental labels. Against the advantage of this broadening influence must be set the loss of more advanced physics courses for it is unlikely that the postgraduate student finding the implications of physics in his new field will have opportunity to attend formal courses in the physics department though, of course, he should be able to attend occasional seminars.

Each individual's career stems from a series of opportunities. No one would question the facilities for postgraduate training which certain industries can offer but it does not follow that its opportunities will be presented to a particular individual. Twenty years ago it was the exceptional student who was allowed the opportunity to undertake research in a University. Today this opportunity is offered to much more average students. Some profit immensely, others do not. Also, as with first class honours graduates, some, outside the fault of the examination system, can disappear into obscurity in their industrial careers. All certainly do not go on to research careers.

J. S. M. Botterill (*Associate*).
Department of Chemical Engineering,
The University,
Edgbaston, Birmingham, 15.

The Institute's Journals

PRINCIPAL CONTENTS OF THE JUNE, 1960, ISSUES

British Journal of Applied Physics : Volume 11, No. 6

Principles of thermoelectric devices. By H. J. Goldsmid.

In recent years, the use of semiconductor thermojunctions has improved the efficiency of generation by means of the Seebeck effect and has made thermoelectric refrigeration a practical possibility. By using semiconducting compounds of high mean atomic weight, Seebeck coefficients of about 200$\mu V/°C$ have been obtained without the ratio of electrical to thermal conductivity departing too far from the value given by the Wiedemann-Franz law for metals. The most favourable semiconductors have been improved still further by alloying with isomorphous materials. Devices employing the thermoelectric effects are discussed.

Choice of frequency for eddy-current tube testing. By F. R. Bareham, A.Inst.P.

Eddy-current testing can be used to detect faults in metal tubes by passing the tube through a pair of short solenoidal coils which are energized by an alternating current. The decrease in density of the induced eddy-currents from the outer surface is determined by the frequency of the energizing current and by the electrical properties and dimensions of the tube. Since the eddy-currents flow in a circumferential direction, their distribution is not, as often assumed in the past, the same as when current flows in the direction of the axis. The distribution of eddy-currents flowing circumferentially is given in general terms for non-magnetic tubes and the results can be used in conjunction with a nomogram to determine suitable frequencies for many practical applications.

Charge localization on the surfaces of oxide-coated cathodes. By B. J. Hopkins, A.Inst.P., and Professor F. A. Vick, F.Inst.P.

Anomalous results obtained while using the Kelvin method of determining contact potential differences between oxide-coated cathodes and an evaporated gold film reference surface in an atmosphere of hydrogen have been investigated. Very high contact potential differences have been associated with a separation of charge from ionized gas on the passage of a discharge current. This charge, either positive ions or electrons, remains on the surface of the oxide cathode for periods (sometimes as long as several days) dependent on the conductivity of the oxide coating. This in turn depends upon the nature of the oxide material, its state of activation and its temperature. Experiments are also described on the behaviour of probe cathodes in hydrogen.

New technique for measurement of low dissolved-air content of water. By D. M. J. P. Manley, A.Inst.P.

A method is described to measure the dissolved-air content of water enclosed in a vessel. This method uses an air bubble and is very suitable for the measurement of the air content of undersaturated samples. Tests have been made of typical specimens and the limitations of the technique are discussed.

Determination of orientation of bismuth single crystals using back-reflexion technique. By H. D. Mallon, and C. G. Wilson, A.Inst.P.

The ambiguity in interpretation of orientation from back-reflexion photographs of bismuth single crystals is resolved by taking photographs about the trigonal axis or the normal to the (111) plane. The trigonal axis which is also the optic axis is uniquely determined by using polarized light.

Measurement of surface stress in austenitic steel. By J. C. Moore, Grad.Inst.P.

A method is described to evaluate macro surface stresses in an austenitic steel. A multi-exposure, X-ray back-reflexion technique is employed, and surface-stress values obtained by this method are compared with theoretical values.

Analogy between the slow motion of a viscous fluid and the extension and flexure of plates : a geometric demonstration by means of Moiré fringes. By T. H. Richards.

That the problems of extension and flexure of plates and the slow two-dimensional motion of an incompressible viscous fluid are analogous is well known. In this paper, emphasis is placed on some of the geometrical properties of the stream function and Airy stress-function surfaces. Through these properties a method is described wherein visualization of flow and stress conditions is obtained by analogy, the flexure problem of plates being the vehicle for solution.

Determination of the elastic moduli of tin single crystals, and their variation with temperature. By D. G. House, Grad.Inst.P., and E. V. Vernon, A.Inst.P.

An apparatus is described for the measurement of the frequencies of resonance of longitudinal and torsional vibrations of circular cylindrical rods at temperatures in the range − 180 to + 190°C. The values obtained have been used to determine the elastic moduli of single crystals of tin over this range of temperature. The equations relating the elastic moduli to these frequencies of resonance for tetragonal crystal symmetry are given. The values of the elastic moduli at 15°C are given as $S_{11} = 41{\cdot}6$, $S_{33} = 14{\cdot}9$, $S_{44} = 45{\cdot}6$, $S_{66} = 42{\cdot}8$, $S_{12} = -31{\cdot}2$ and $S_{13} = -4{\cdot}8$ in units of 10^{-13} cm^2 dyn^{-1}.

Measurement of atomic differential scattering cross-sections. By J. S. Halliday, F.Inst.P.

The derivation of the atomic differential-scattering cross-section $(d\sigma_T/d\omega)_\theta$ from the intensity distribution in the background of electron diffraction patterns is discussed, bearing in mind the possible effects of plural scattering. It is shown that the variation of $(d\sigma_T/d\omega)_\theta$ with specimen thickness reported by Haine and Agar is not real but appeared because the decrease in the unscattered intensity was over-estimated. After correction, their values for $(d\sigma_T/d\omega)_\theta$ are in reasonable agreement with Lenz's theoretical values for angles between 10^{-3} and 2×10^{-2} radians, but the experimental rate of decrease of $(d\sigma_T/d\omega)_\theta$ with increasing angle is smaller than expected. The effect of plural scattering on the intensity distributions from thicker specimens is not as great as that predicted by Lenz.

Journal of Scientific Instruments : Volume 37, No. 6

Compensated Wheatstone's bridge circuit for gas-chromatographic catharometry. By A. B. Littlewood.

Drift of the base line caused by imperfect control of temperature or voltage of a gas-chromatographic catharometer may be eliminated by including one shunt and one series resistance with the catharometer hot elements in the Wheatsone's bridge circuit. Equations enabling the positions and values of the resistances to be calculated from the observed drift are given. Experience shows that use of the compensating resistances enables a catharometer to be used more sensitively without the trouble and expense of careful temperature and voltage control.

Transistor cup anemometer. By R. R. McGregor.

A remote indicating cup anemometer is described in which transistor electronics have been applied to obtain a compact instrument, operating off small dry batteries and capable of registering wind speeds down to 0·2 m/s.

Photoelectric comparator for Rayleigh fringe electrophoresis patterns. By C. C. Curtain.

A photoelectric fringe comparator for scanning electrophoresis plates, based on a microdensitometer, a Schmitt-trigger operated counter and a recording milliammeter is described. The basis of the microdensitometer is a standard Zeiss binocular microscope with a mechanical stage driven by a reduction gearbox. A considerable simplification in the electronic circuit of the densitometer is achieved by using highly sensitive type ORP90 cadmium sulphide photoconductive cells.

Rand soil-pressure cell for low pressures, high accuracy and long-term stability. By Prof. J. E. Jennings, and J. B. Burland.

The cell is of a " balanced pressure " type and a linear differential transformer is used as a null point indicator to maintain a diaphragm in its zero position. The deflexions of the diaphragm during pressure measurement may be kept very small, well within the limits required for soil pressure cells. The cell is used for direct and tangential pressures on the face of a rigid wall containing consolidating silt. The accuracy of observing the pressures lies within $\pm 0{\cdot}04$in head of oil.

R.F. admittance bridge for liquid-dielectric measurements. By R. G. Bennett.

An admittance bridge is described suitable for the measurement of the complex permittivity of liquid dielectrics at frequencies between 100 kc/s and 3 Mc/s. The unknown capacitance is compared directly with a standard capacitor, while the conductance arm may be simply calibrated on a direct current supply. Component values are given suitable for use with a cell having an empty capacitance of 5 pF. No Wagner earth is necessary when using a 3-terminal cell, since the balance condition is independent of admittancies between the electrodes and the guard electrode.

Equipment for the encapsulation of semiconductor devices. By R. D. Knight.

A hydraulically operated ram carries the semiconductor device and its envelope, loosely assembled, into a Pyrex chamber. Here the two are separated while the envelope is outgassed by e.c.h. in vacuum. They are then brought together, in vacuum or in gas, and the residual heat in the envelope melts a ring of tin in the mount collar to make the final seal. During the process the device is warmed sufficiently to drive off any moisture. A novel three-port valve controls the gas and vacuum supplies to the chamber. The equipment has been designed with a view to ultimate automation.

Tilting and rotating specimen stage for electron microscopy and electron diffraction. By R. E. Burge and H. R. Munden.

The importance of tilting and rotating the specimen in electron microscopy and electron diffraction is discussed. The design and construction of a specimen stage, allowing a maximum tilt of 35 deg. of the plane of the specimen from a plane perpendicular to the electron beam, and providing a 360 deg. rotation at all angles of tilt are described. Though the stage has been designed specifically for the Metropolitan-Vickers type E.M.3 electron microscope, the principles involved may have application to other microscopes.

Use of a liquid scintillator counter for beta particles. By T. B. Ryves.

A simple counting technique is described for the absolute counting of beta particles using a 4π liquid scintillator counter technique. The radioactive sample is deposited on a thin backing film of transparent material, which is then immersed in the liquid scintillator. It was found that for samples with a maximum beta particle energy greater than 0·7 MeV the detection efficiency was close to 100%, comparing favourably with other methods of absolute counting.

Epoxy-resin joints for sealed-off, high-vacuum tubes. By J. F. Sayers, Grad.Inst.P.

The paper describes how joints may be made in the envelope of sealed-off, high-vacuum tubes using a synthetic resin adhesive, permitting unusual forms of construction. A pressure of 10^{-6} torr may be maintained in such a tube for several years. Success depends on suitable design and processing and on the use of getters. A special television camera tube and a vacuum photocell have been made using this technique.

High frequency light modulation. By R. L. Williams.

High frequency light modulation has been realized using a magnetically driven rotor suspended by a magnetic field in a vacuum chamber. With a rotor 1 in. in diameter having 180 reflecting faces, modulation frequencies in the megacycle region are readily obtainable. Design considerations are given for the rotor described, together with details of the driving and suspension circuit employed. A time constant measurement for an indium anitmonide sample is given as an illustration of the system.

Beam method for the measurement of internal friction. By J. E. Thompson.

The oscillatory motion of a swinging beam used to measure the internal friction of a silicon-iron strip has been found to be complicated, and to consist of a small amplitude, higher frequency oscillation superimposed on the main oscillation, so that difficulty arises in obtaining a unique value for the logarithmic decrement of the strip oscillation. The motion has been analysed and reasonable agreement is found between the experimental results and the theory developed.

Technique for replicating fibre surfaces by rolling. By J. Mølgaard.

Short lengths of fibre with cylindrical cross section are placed on a plastic film and rolled, thereby replicating the entire fibre surface. The apparatus to do this is described. The replicas are examined by phase contrast. Nylon fibre surfaces are illustrated.

Laboratory magnetic elutriator for purification and isolation of ferrimagnetic mineral sands. By W. R. B. Martin.

An apparatus is described which allows almost total removal of not-completely homogeneous magnetic grains from ferrimagnetic mineral sand, and will further separate strongly remanent from weakly remanent grains. Magnetic-field strengths and water-flow velocities required for material of size 60 to 200 B.S. mesh, and a scale drawing of the separation tube are given.

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